Masonry Heater Association Of North America

MHA News

Volume 7 Number 1 Spring 1994

Success In Colorado

In a landmark event, Colorado has ammended its tough clean air legislation to specifically include masonry heaters.
The last issue of MHA News carried details of the ongoing negotiations with the Colorado Air Quality Control Commission. The effort was spearheaded by MHA member Walter Moberg of Fire Spaces (Portland, Oregon).

Rick Crooks, Past President of MHA stated that "MHA members should be aware of the tremendous effort that Walter made for the association. I know that we would not be able to "celebrate" this new regulation without his dedicated effort. Also, the assistance and direction provided by HPA (Hearth Products Association) through John Crouch and their attorney, David Menotti, was invaluable. The MHA membership needs to thank these people for their work."

Walter sent in the following draft announcement:

In This Issue

For several years now, the State of Colorado has banned wood-burning firepl38

aces and wood-burning masonry heaters; in fact, the only wood-burning appliances allowed have been E.P.A.-certified woodstoves and, recently certain pellet stoves. While most states have continued to exempt masonry heaters that weigh over 800 kilograms (1761 lbs), as was allowed in the national E.P.A. certification program, some jurisdictions (like Colorado) have not honored these exemptions,requiring certified units only. Now the Colorado Air Quality Control Commission has approved an amendment to its Regulation 4, written largely by the Masonry Heater Association (MHA), that will allow clean-burning masonry heaters to receive approvals as well.

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R2000 Discussion Heats Up

by N. Senf

R2000 is a voluntary Canadian housing performance standard. Among other things, it requires a reduction in house energy consumption of 50% compared to conventional housing. Masonry heaters were excluded from R2000 in 1992 when an "EPA-certified stoves only" rule was added. The main issue, however, was not emissions. Rather, it was air consumption. For an in-depth discussion, see the Spring 93 issue of MHA News.

Since then, the discussion has advanced through several rounds of meetings and letter/fax exchanges. Quite a number of issues come into play and, not surprisingly, a range of opinions has been expressed by different parties. It also highlights some of the areas in which MHA needs to enhance its communication structure. If you were not able to attend the Reno meeting, then you have not had any input to these discussions. The only medium we have so far for informing the membership at large is this newsletter, which, of necessity, often lags several months behind events. Elsewhere in this issue you will find my pitch for getting MHA on the information highway with E-mail (electronic mail). This would give any member with minimal

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Masonry Heater Association Of North America MHA News

Volume 7 Number 1 .... Spring 1994

Published by:

The Masonry Heater Association of North America

Elected Officers: 94/95

President	*Pat Manley*
Vice President	*Ron Pihl*
Secretary	*Tina Subasic, P. Eng.*
Treasurer	*Lucille Frisch*

Business Office:

Administrator: Tina Subasic, P. Eng.

The Masonry Heater Assoc. of N. America
11490 Commerce Park Drive
Reston, Virginia 22091

Telephone 703/620-0010
FAX 703/620-3928

Editorial Office:

Editor *Norbert Senf*
c/o
Masonry Stove Builders
RR 5, Shawville
Québec J0X 2Y0

Telephone 819/647-5092
Fax 613/722-6485

Membership Policy:

Membership is open to anyone with an interest in masonry heating .

Annual membership dues:

Voting	200.00 (US)
Associate	100.00 (US)

IMPORTANT NOTE: Please check the membership list in the current issue and notify us immediately of any errors in your address, phone numbers, or dues status. Voting members are entitled to a set of in print back issues of MHA News.

Contact the Editor if you haven't received your back issues or if the information published in this issue's membership list needs correction.

MINUTES OF 1994 MHA ANNUAL MEETING

MARCH 10 - 11 RENO NV

A meeting of the MHA Board of Directors was held on the evening of Wednesday, March 9 at the Holiday Inn, Reno.

The Annual Meeting commenced on Friday, March 10 at the Reno-Sparks Convention Centre.

Attendees:

Name	Company	Voting
Rick Crooks	Mutual Materials	y
Tina Subasic	Brick Institute of America	y
Nobert Senf	Masonry Stove Builders	y
Jerry Frisch	Lopez Quarries	
Lucille Frisch	Lopez Quarries	y
Erik Nilsen	Thermal Mass Inc.	y
Heinz Flurer	Biofire Inc.	y
David McGee	Masonry Concepts	y
Ron Pihl	Cornerstone Masonry	y
Dale Hisler	Lightning Arrow Stoveworks	y
Stanley Sackett	Sackett Brick Co.	y
David Moore	MTC Construction	y
Cheryl Barden	Maine Wood Heat Co.	y
Jamie Paiken	Jamie Paiken Masonry	y
Doug Fry	Fry Masonry Construction	y
Bill Derrick	Alternate Energy Systems	y
Jay Hensley	SNEWS	
Jerry Haupt	Kent Valley Masonry	y
Stig Karlberg	Royal Crown European Fireplaces	y
Thomas Stroud	DWS	y
Stephen Bushway	Deer Hill Masonry Heat	y
John LaGamba	Temp-Cast	y
Jim Donaldson	European Masonry Heater Co.	y
Walter Moberg	Walter Moberg Design Inc.	y
John Crouch	HPA	
Dr. Ernst Rath	Rath Refractories	
Matheus Rath	Rath Refractories	
Jack West	Tulikivi	y

Welcome

The meeting was called to order by president Rick Crooks at 9:00 AM and an opening statement was given by Rick. A roll sheet for sign-up was distributed and introductions were made.

Masonry Heater Research Papers

Rick brought along copies of various technical papers. Due to the number and size, sign up sheets were set up for the individual papers so that members could order copies of the ones that they were interested in and be billed directly.

1993 Minutes

Minutes of the 1993 Meeting in Nashville were published previously in MHA News and were accepted.

Treasurer's Report

Lou Frisch presented a Treasurer's Report:

Masonry Heater Association Expenditures 1993

Expenses:	
Newsletter	423.74
B.I.A. (Administration)	803.20
Bank Charges (includes returned check & charges on Canadian checks)	269.81
New Brochures	3762.20
Nashville MHA Booth (Decorator plus 50% of Tina's expenses)	506.68
Misc. (Barnett flowers & Ev. Screen Graphics for T-shirts)	420.73
Accounting Fees	0
M.H.A. Testing	0
Total Expenses	5,323.16
Checkbook balance as of 12/31/93	11,785.43

1993 Financial Summary

1/1/93	6,138.03
1993 Income	10,970.56
1993 Expenses	5,323.16
12/31/93 Ending Balance	11,785.43
1993 Net Income	5,647.40

MHA Expenditures from 1/1/94 through 3/5/94

Newsletter	650.50
B.I.A. (Administration contract and postage)	198.00
Misc. (Everett Screen Graphics)	138.77
Emission charts & Overhead Outlines for MHA in Colorado	345.00
Reno MHA booth (table and chair)	172.00
Reno MHA (audio visual)	122.00
Reno MHA (catered membership lunch at annual meeting)	582.13 (2 days)
Accounting expenses for IRS status (Brown & Tate)	947.00
Expenses to date	**3155.40**
Checkbook balance as of 3/5/94	16,430.03
94 Income from dues and brochures	7,800.00

1994 Financial Summary To Date

1/1/94 Beginning Balance	11,785.43
1994 Income to date	7,800.00 as of 3/9/94
1994 Expenses to date	3,155.40 as of 3/9/94
3/9/94 Balance	**16,430.03**

1995 ANNUAL MHA MEETING WILL BE IN LAS VEGAS, MAR 22 -26

Rick Crooks reported on corporate status for MHA and our IRS situation. Since MHA did not complete IRS not-for-profit corporation application, payment of back taxes and associated interest/penalties were authorized, covering 1991 and 1992. A final filing was made by the "taxable" MHA for 1992. Application for a new, not-for-profit status will be made by Rick Crooks, Lou Frisch for the 1993 tax year. The association's CPA tells us we have a 15 month filing deadline for this "1024" application. A new corporation will be created, registered in the State of Washington.

Business

Tina Subasic presented an Administrator's report, with discussions of the HPA Expo booth.

Tina went on to propose a rewrite of BIA Technical Notes for Brick Construction, issues 19D and 19E (masonry heaters). If members would edit and/or rewrite the notes, BIA would consider reprinting. In the event that BIA declined to print, MHA may elect to sponsor the printing. Tom Stroud, Jerry Frisch and Cheryl Barden volunteered to oversee the rewrite.

BIA Report

Several items of correspondence and PR work by Tina were discussed.

Slide Program Development

Tina requested that any additional slides from members wishing to be included in the MHA slide program submit them to her by April 1, 1994. Tina will assemble slides and a script to made available for purchase by the membership. Order form will appear in future MHA News mailings.

> CHANCES LOOK VERY GOOD FOR AN OFFICIAL ASTM MASONRY HEATER STANDARD SOON

Stan Sackett offered to submit a proposal for conversion of the slides to video format, using local cable station assistance.

Skip Barnett Video/Slides

Tom Stroud has the slides and video of Skip's Phoenix PM-10 Air & Waste Management seminar on residential wood combustion issues. Tom will forward these to Tina for copying and placing in the MHA office. The unedited slides and video would be available for purchase, announcement and prices to appean in MHA News.

MHA Marketing Leads

Stig Karlberg reported on MHA marketing and leads activities for the past year. Members are reminded that if they wish to receive copies of leads that come in to the MHA office, they should forward a supply of self-addressed stamped business size envelopes to Stig at Royal Crown.

HPA/MHA Brochure

Stig Karlberg and Walter Moberg reported on the development of the HPA/MHA brochure. The item was tabled for discussion until the HPA Masonry Heater Caucus meeting, Sunday.

Europe Trip

Bill Derrick discussed the benefits of a Europe trip investigating masonry heater construction, testing, and material supply. Several options jfor travel were discussed, including the possibility of visiting an Austrian trade show. Bill will prepare a proposal for 1995 trip.

Austrian Research

At 11:00 AM, Dr. Ernst Rath and his son Matheus arrived from Austria and gave a presention on new regulations in Austria, current emissions research (see report elsewhere in this issue) , current radiant heating research at the Technical University at Vienna, his company's new Kachelofen program, and possibilities for collaborative efforts with MHA.

Regulatory Activity

At 12:00 noon, a working lunch was served in the meeting room and discussions were held on current regulatory activity.

John Crouch, HPA's emissions and regulatory specialist, presented a regulatory update on Northern Sonoma county.

Walter Moberg reported on Colorado (see report in this issue)

Norbert Senf reported masonry heater air consumption research for CMHC, and on discussions with R2000 (see reports elsewhere in this issue).

Tom Stroud gave a British Columbia update (see report on BC elsewhere in this issue), and an update on Northern Sonoma county (proposed fireplace bans).

Rick Crooks presented a discussion on the need for an MHA "Position Paper" favoring a review of memo regarding R2000 program from Norbert Senf. This item would be discussed later in the meeting.

Planning Session

At 1:00 PM Jerry Frisch led a planning session for MHA's training/certification program. Jerry reported that the WETT and HEARTH manuals were distributed to the Training/Certification task group, and some comments were returned. Discussion followed about incorporation of these programs as pre-requisites for MHA training. It was concluded that the task group continue to work on a Training Program as opposed to a Certification program, and that the training program be for site-built "custom" heaters, not manufactured component models.

Field Testing Update

At 2:30 PM Paul Tiegs from OMNI Environmental Services, Inc. presented an update on current field testing activity in the woodburning field. Paul reported that the OMNI/SAIC "merger" was unsuccessful, and that OMNI will continue as a separate identity, available for consulting and testing with masonry heater builders/manufacturers.

ASTM Task Group Meeting

At 3:00 PM there was an ASTM Task Group meeting, with Rick Curkeet (chairman E-6.54 Subcommittee) and David Johnston (independent consultantt and contributor to the proposed standard) attending. The standard has been designated ASTM E 1602, and was sent to society ballot, due Monday, March 15. However, ASTM Editors rejected the E-6 committee approved "editorial" changes made to the standard after the last ballot. The standard will now be sent back to committee and subcommittee for a simultaneous reballot. Tom Stroud will vote negative on the standard at Society level, based on recommendations of ASTM staff. Tina will prepare a new copy of the proposed standard for the simultaneous ballot this April. The standard can be made available this year if balloting goes well.

RICK CROOKS NOTED THAT THIS WAS THE FIRST TIME IN MHA'S HISTORY THAT THERE HAS BEEN A BANK BALANCE OVER AND ABOVE OPERATING COSTS.

Planning Session (continued)

Training/Certification

At 4:00 PM the planning session for training and certification was continued. Task groups were set up with a mandate to report back to the meeting on Friday with proposals for action and funding.

The meeting adjourned at 6:00 PM, and was reconvened on Friday March 11 at 9:00 AM

Business

Elections

First item of business was election of new officers. Nominating Committee of Rick Crooks and Jerry Frisch presented a slate of candidates as follows:

Executive:

President	Pat Manley
Vice-President	Ron Pihl
Secretary	Tina Subasic
Treasurer	Lucille Frisch

Board of Directors:

Jack West, Heinz Flurer, John LaGamba, Jerry Haupt, Walter Moberg

Election was by a show of hands, and above candidates were elected unanimously.

Next item was a presentation by Norbert Senf on two new papers "Air Requirements and Related Parameters for Masonry Heating Systems", for CMHC (Canada Mortgage and Housing), and "Recent Laboratory and Field Testing of Masonry Fireplaces and Masonry Heaters" for AWMA (Air and Waste Management Association.) (See reports elsewhere in this issue.

Proposal for Testing at Lopez Labs

Next item was a report by Jerry Frisch and Norbert Senf on current status of testing at Lopez Labs. Rick Crooks tabled a letter from Ulli Baumhard endorsing MHA support of further test efforts. Testing was felt to be important to the industry at large, in particular designers of custom heaters. Funding so far has been exclusively by Lopez Quarries and Masonry Stove Builders. Although a percentage of it can be attributed to product development, continued testing was posing a financial hardship for both companies and was no longer justifiable strictly as product development, since most of it is generic and published. Low cost test slots had been offered to manufacturers, and participation by Tulikivi has funded hard costs (lab improvements and consumables) for 94. See 1994 Budget, below.

PRESIDENT	PAT MANLEY
VICE-PRESIDENT	RON PIHL
SECRETARY	TINA SUBASIC
TREASURER	LUCILLE FRISCH

1995 Annual MHA Meeting

At 12:00 noon, working lunch was again served in the meeting room. Tina Subasic led a discussion regarding the time and location of the 1995 annual MHA meeting. It will again be with HPA (Mar 24 -27), and will be in Las Vegas. Tina will look at the Stardust Hotel as a potential lodging and meetin site.

1994 Budget

The 1994 budget was the next item on the agenda. Rick Crooks noted that this was the first time in MHA's history that there has been a bank balance over and above operating costs. It was suggested that a reserve fund be set up, and that funding proposals for 1994 activities be entertained.

Operating expenses for the remainder of the 1994 year were estimated not to exceed $5,000 based on the following:

Newsletter	1,800
BIA Administration	1,000
CPA, Taxes	1,000
Meeting Expenses	200
Total Projected Expenses	5,000

Available funds (current checkbook balance) shows approximately $17,000, leaving $12,000 available for this year's programs

Lopez Labs Testing Sponsorship: Norbert Senf requested $1,500 to help offset overhead expenses and to sponsor his writing of a summary test report to be made available to the membership. Approximately $500 of this money would be used to bring Paul Tiegs of OMNI to the laboratory for consultation and evaluation of the Lopez facility. Approved. (See preliminary report elsewhere in this issue.)

BIA Tech Notes Reprinting: Tina estimated about a $5,000 bill for printing the 19D and 19E Tech Notes should BIA not fund them this year. It was decided to wait for the rewrite of the document and BIA's printing decision before MHA would consider funding this item.

Press Release/Public Relations Program: John LaGamba requested that the association fund writing of MHA press release by a professional firm (the firm currently used by BIA was suggested as a starting point).

TINA REQUESTED THAT ANY ADDITIONAL SLIDES FROM MEMBERS WISHING TO BE INCLUDED IN THE MHA SLIDE PROGRAM SUBMIT THEM TO HER BY APRIL 1, 1994. TINA WILL ASSEMBLE SLIDES AND A SCRIPT TO MADE AVAILABLE FOR PURCHASE BY THE MEMBERSHIP. ORDER FORM WILL APPEAR IN FUTURE MHA NEWS MAILINGS. STAN SACKETT OFFERED TO SUBMIT A PROPOSAL FOR CONVERSION OF THE SLIDES TO VIDEO FORMAT, USING LOCAL CABLE STATION ASSISTANCE.

John also outlined a method be where member companies could share the leads coming from the release publishing for a nominal fee, providing a self-funded program. Suitable topics for the release were discussed: ew MHA officers; anticipated successful regulation rewrite in Colorado; Lopez testing, and other issues. Tina Subasic would assist the search for a professional firm. This item was funded not to exceed $2,000. Approved. (See report elsewhere in this issue.)

Colorado issues were discussed. Walter Moberg has had to make several trips to Colorado to deal with regulators. MHA to pay expenses for 1 trip that he was not able to combine with other business. Approved.

Training Course Outline: Norbert requested funding for the development of a training course outline and program proposal. Norbert estimated the start-up of the full program could be funded with $3,000 to $6,000, but that this would depend on the course outline to be developed along with the program definition and scope. This item was funded not to exceed $400.

Regulatory Participation: Estimated out-of-pocket costs of 500. were approved for Norbert Senf to present Masonry Fireplace/Heater paper at 1994 AWMA Conference. This was a solicited paper and will be published in the Conference Proceedings. Approved. (See AWMA paper elsewhere in this issue.)

R2000: Final item on the agenda was presentation of a memo regarding R2000 proposals for consideration by the membership present. Some vigorous discussion ensued, and consensus was reached on several items. (See R2000 report elsewhere in this issue.)

Meeting was adjourned at 1:00 PM.

Other Activities during HPA show:

2 - 3PM Toolbox Session - Panel discussion on Masonry Heaters - Convention Centre

There was an MHA banquet at 7:00 PM at a local eatery. Old executive was retired with thanks and speeches, and new executive was welcomed with festivity.

Saturday March 12:

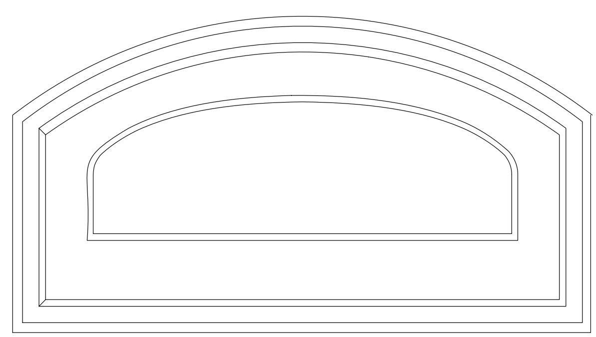
9 M - 5 PM HPA Exposition Open

11 AM - 12 PM HPA Toolbox Session on Masonry Heaters

5 PM - 7 PM ` HPA Industry Reception

Sunday March 13

9:30 AM - 10:30 AM HPA Masonry Heater Caucus Meeting



New Members

MHA Extends a Warm Welcome to the Following New Members:

VOTING

Steve Cohan
Hot Rock Masonry
PO Box 526, Rt. 1, Box 85-S
Eastsound
WA 96245

Kerry Hill
Cross-Fire Heat Storage Systems Inc.
12159 Brawn Rd.
RR #2
Wainfleet
ON L0S 1V0

Arthur Olson/Jim Donaldson
European Masonry Heaters Co.
706 California Blvd.
Napa
CA 94559

Jamie Paiken
Jamie Paiken Masonry
600 Cove Rd.
Ashland
OR 97520

Keith Roosa
Hickory Mountain Chimney Sweep
P.O. Box Q
Wallkill
NY 12589

Robert A. Rucker
CMS Industries Inc.
4524 Rt. 104
Williamson
NY 14589

Rod Zander
Artisan's Workshop
127 North Street
Goshen
CT 06756

ASSOCIATE

Larry James
High Country Stoves
415 S. 5th. St.
Laramie
WY 82070

Al Bachmann
Bachmann Construction
45 Burroughs Dr.
Madison
WI 53713

NEW RESEARCH RESULTS FROM AUSTRIA

One of the highlights of the 1994 MHA Meeting was a visit from Dr. Ernst Rath and his son, Matheus, from Austria. Dr. Rath's company, Rath Refractories, is Austria's oldest refractory company. They have two divisions: industrial refractories and stovebuilder's refractories. A new American division, Rath Performance Fibres, deals in industrial refractories on this continent.

Matheus Rath has been obtaining his doctorate at the Technical University of Vienna, with a thesis on masonry heater emissions.

Below you will find a transcript of his presentation to MHA, captured by my trusty microcassette:

Dr. Rath:

In the last few years the Austrian stovebuilding industry has recognized that there is no possibility in the future of working with stoves like they were built in the last century in Austria, because of emissions. Therefore, we decided to sponsor two theses at the Technical University of Vienna, in order to see whether we can meet all of the new emissions requirements, which are becoming more and more severe in Austria.

One of the theses addresses the technical requirements of stoves, ie., how can we fire the stoves in a manner that will deal with the emissions requirements.

IN THE LAST FEW YEARS THE AUSTRIAN STOVEBUILDING INDUSTRY HAS RECOGNIZED THAT THERE IS NO POSSIBILITY IN THE FUTURE OF WORKING WITH STOVES LIKE THEY WERE BUILT IN THE LAST CENTURY IN AUSTRIA, BECAUSE OF EMISSIONS

The other thesis addresses radiation (radiant heating), and also how masonry heating relates to the economy and the environment. For example, in overall economic terms, how does biomass combustion compare with fossil fuels?

These theses have now been completed and the findings presented. One of these was written by my son, and that is the reason we have come here today, so that he can give you all the details directly, so that they don't have to be translated first.

Finally, in order to meet all of the emissions

requirements, we have developed computer-aided design software that can perform the calculations on firebox dimensions, etc., and then do automatic material takeoffs. We want to ensure that all masonry heaters are constructed in accordance with the new requirements, and that is why we developed this program. I would suggest that after the discussion we show you this program, because it may also be applicable here, and can be purchased from the Kachelofen Verband (Stovemasonry Guild) in Vienna.

Matheus Rath:

I'm very glad to have this opportunity today to present to you some of the latest scientific findings in traditional stove design.

The first item is the new emissions limits that we have in central Europe (see illustration).

Secondly, I'd like to talk about some new research results - that "wood is not wood", in other words, wood is not all the same. There is quite a bit of variation between species. Beech and fir, for example, are quite different with respect to emissions performance.

Next, I would like to show you new design software that has been developed to aid in the calculation and dimensioning of stoves.

Finally, I'd like to discuss our conclusions, and what we feel the necessary design changes are in order to improve stove performance.

(See illustration, first page) Here is a chart of the CO limits for Central Europe in grams per kilogram. As you can see, the Austrian limits are still quite high. but in 1995 they will be lower than in Germany. In order to attain the 1995 limits, improvements need to be made in stove design. In the next slide (see illustration) you will see Austrian limits for other pollutants. You will note that the province of Styria has its own limits, and that they are stricter than for Austria as a whole. In particular, the oxides of nitrogen emissions are much lower.

The next slide (see illustration) shows you where we are at right now. The Bio combustion chamber is one where the air comes in from all sides. In the normal combustion chamber, the firebox loading door is left open during the whole burn in order to supply air. In the Bio combustion chamber, there is a separate door to control the air supply. The air door is left open for the whole burn, and the loading door is just left open during startup.

We can see from the chart that with traditional stoves, we have no problems meeting the CO and the particle emission limits for 1995. For particles, the limit is 1 g/kg, and we are only getting a quarter of that.

The problem we have, as you can see, is with the oxides of nitrogen (NOX) emissions. This brings me to the next point. We analyzed the different wood species for nitrogen content and found that there was quite a variation, (see chart) for example, acacia has twice the nitrogen content of spruce or fir. We learned that all of the NOX emissions result from the nitrogen in the fuel - if you have double the nitrogen content in the wood, then you get double the oxides of nitrogen emissions.

(Question) What is a briquette.

<u>Matheus Rath</u>: briquette is composed of compressed wood chips, without additives. It is 10 inches long with a diameter of 3 to 4 inches, and has a 1 inch hole through its centre, lengthwise.

"Wood is not wood" also means that the wood composition is variable within the piece of wood itself. The bark especially has a high nitrogen content. The next slide shows the structure of a piece of firewood, and in the following slide we see the nitrogen content of the different parts of the wood. You can see that there is quite a bit of variability, and that there is a big difference depending on whether we burn the wood with the bark or not. It is very important to inform regulators of the fact that it is possible to reach the 1995 NOX limits with fir, but that it is not possible with beech or with acacia.

(Tom Stroud): So you are saying that it is better to burn wood without the bark (Answer: yes). I don't know whether you are aware of it or not, but in North America the standard wood for testing is fir (Douglas Fir) without the bark (laughter from the audience).

<u>Matheus Rath</u>: In Europe it is not defined - you can use whatever wood you want to.

<u>Dr. Rath</u>: One of the problems is that when they set the emissions limits in Styria, they had data that was obtained with fir fuel. They therefore set the emissions limits very low. This was one of the reasons that we investigated this, because we didn't know why the numbers from their testing were so much lower.

<u>Matheus Rath</u>: On the next graph, we see how test results differ when we change wood species. You can see from the CO_2 curve that the two burns are very similar in progression. However, on the NOX graph we can see much lower emissions with fir than with beech. The NOX emissions for beech are double what they are for fir.

On the next slide we see a schematic of our test setup. It is a standard Grundofen system, except that we have separated the firebox and the heat exchanger section. This allows us to change fireboxes without having to rebuild the whole stove every time. At the top of the diagram we see a bank of gas analyzers, which allows us to calculate CO, CO_2, NOX, etc. Down here where the filter is is

YES, THE TESTING METHOD WE USE IS ACCORDING TO AUSTRIAN STANDARDS. IT IS NOT THE SAME AS THE METHOD YOU USE OVER HERE. IT IS A LOWER PARTICLE EMISSION THAN YOU WOULD GET

where we measure particle emissions. We change filters every 30 minutes.

(Norbert Senf) Are the gases going through the filter hot? (Answer: Yes, we are using the normal European standards.)

So, for example, tar particles that would go through the filter when they are hot - what happens to them? (Answer: they go through.)

When we measure particulates in North America, the smoke goes through a dilution tunnel in order to cool the gases before they are filtered. This is done to capture certain tars that only condense and become particles as they are cooled - so you would get a different catch on the filter, depending on whether it was hor or cold. In German, the term used is “Staub” (Yes,). Translated into English it is “dust”, which to us would mean soot and fly ash (Yes,). When particulates are measured in North America, condensible tar particles are measured as well as soot and fly ash. I’m trying to figure out how the two methods relate.

Matheus Rath: Yes, the testing method we use is according to Austrian standards. It is not the same as the method you use over here. It is a lower particle emission than you would get. (Discussion)

The next item that I would like to show you is the stove calculation program that the Austrian Stovebuilder’s Guild has developed. It runs under Windows. On the first screen, the first thing we choose is the size of the stove, ie., the output in kW. We enter the altitude above sea level, the height of the chimney (very important), and how often the stove is fired (the heating cycle). Then we choose whether we want a normal combustion chamber or a Bio combustion chamber. We then enter additional chimney data: round or rectangular flue, flue diameter, and chimney construction.

The program then proposes a set of combustion chamber dimensions, which you can either accept or change. If you change one dimension, then the others are adjusted automatically. If the dimensions you enter are not right, then you get information as to what is wrong.

On the next screen, you can design the geometry of the gas channels. If the configuration doesn’t conform to acceptable design guidelines, this is flagged interactively.

WE KNOW HOW THE STOVES BEHAVED AND WHAT THE ACCEPTABLE RANGES FOR THE CRITERIA ARE SO THAT THE DESIGN WILL FALL WITHIN THE NEW EMISSIONS GUIDELINES

You can choose which manufacturer’s modular units you wish to use, and the channel design is automatically constrained to the use of these modules. Once the design is finalized, the program does an automatic material takeoff, prepares a purchase order, and calculates costs, total weight, and availability from inventory.

Dr. Rath: The design guidelines that this program uses are taken from three stoves that were built and tested at the Technical University. From the tests, we know how the stoves behaved and what the acceptable ranges for the criteria are so that the design will fall within the new emissions guidelines.

Matheus Rath: I’ve got a couple of slides here. You can see from the tests that the chimney height was very critical. The emissions performance was very dependent on the right chimney height.

(Norbert Senf) In other words, if your chimney is lower you have to open up your channels, and vice versa?

Matheus Rath: Yes, that’s right.

On the next slide, we see the emissions limits for cordwood fuel compared to the limits for other fuels. You can see that the limits for cordwood are very high. The target of our research efforts is to reach the same emissions as fuel oil. You can see that the NOX are very high if you use light fuel oil.

So, what do we have to do in order to get a better stove?

First, the carbon monoxide emissions. We need a secondary combustion chamber, because we need more than 650 C or 1200 F to get an absolutely complete burning out of CO. So, we need insulation in order to maximize combustion temperatures in both the primary combustion chamber and the secondary combustion chamber. We need about 2 inches of ceramic fiber.

Dr. Rath: It sounds paradoxical to insulate the combustion chamber, but you need to get the high temperatures, and then you can transfer the heat out later on.

Matheus Rath: Yes, we divide the stove into two parts - first, the combustion chamber and second, the ceramic heat exchanger.

So, what do we want? We want good combustion temperatures, and we want good heat exchange. So we insulate the combustion chamber, and we optimize the ceramic heat exchanger.

What can we do with the NOX emissions? We need a three stage combustion. So we need another zone between the primary and the secondary combustion zones. We need a reduction zone in which we can utilize the CO to chemicallly reduce (ie., subtract oxygen) from the NOX. If you have a lot of CO, you get very low NO emissions. So we can use a high CO zone to burn out the NOX. Finally, with the NOX gone, the gases enter the secondary combustion zone where secondary oxygen is added and the CO is burned.

(Question) What do you mean by reduction?

(Answer) Reduction is a chemical reaction that is the opposite of oxidation. In other words, you subtract oxygen in the reaction rather than adding it.

Matheus Rath: In the reduction zone we have about 10% CO, 16% CO_2 and there is no free oxygen. When we get into the secondary combustion zone we add more oxygen in order to complete the burn.

(Tom Stroud): How does this relate to the typical Grundofen configuration of a Fallzug and an Abzug (the firebox exits into a downdraft channel followed by an updraft channel).

Dr. Rath: You would add the air in the Abzug.

Matheus Rath: In the slide here we see first the main firebox, where air is introduced from all sides. The top half of the firebox is insulated. Then we exit into an insulated downdraft chamber where the reduction takes place. At the bottom of the reduction chamber, we add air as the gases change direction and go into an insulated updrafting secondary combustion chamber.

IN THE SLIDE HERE WE SEE FIRST THE MAIN FIREBOX, WHERE AIR IS INTRODUCED FROM ALL SIDES. THE TOP HALF OF THE FIREBOX IS INSULATED. THEN WE EXIT INTO AN INSULATED DOWNDRAFT CHAMBER WHERE THE REDUCTION TAKES PLACE. AT THE BOTTOM OF THE REDUCTION CHAMBER, WE ADD AIR AS THE GASES CHANGE DIRECTION AND GO INTO AN INSULATED UPDRAFTING SECONDARY COMBUSTION CHAMBER

(Tom Stroud) How does it affect the nitric oxide in the reduction zone? You have the nitrogen there. Are you pulling the oxygen off the nitrogen?

Matheus Rath: There is fifty percent less nitrogen than oxygen.

(Norbert Senf) When you pull the oxygen off the NOX then you are left with nitrogen.

(Tom Stroud) Right. So then it goes into the next chamber and you’re adding oxygen. It doesn’t go back to oxygen again?

Matheus Rath: No. It is only a problem if you have temperatures which are higher than 1100 C in the secondary combustion chamber. If the temperatures are too high, you get new nitric oxides. So you need a temperature that is high but not too high. We regulate this with a computer that controls the primary air and the secondary air. If you have the right settings on the air controls, then you get low emissions.

(Question) In a real world situation where the homeowner is operating the stove, how practical is it going to be to operate in such a fashion?

Matheus Rath: This is a real problem. You have to regulate the oxygen accurately, and we are developing computerized controls that will do that.

(Tom Stroud) What you have to understand is that this is what will keep the masonry stove industry ahead. This is far ahead of anything that the metal stove industry can do. This is probably five or ten years down the road in the United States, but eventually they are going to be looking at all the same things. Its not going to be tomorrow but its going to be soon.

SUCCESS IN COLORADO

Continued from page1

This landmark decision will provide the first detailed approval procedure for masonry heters in North America. The E.P.A.,which has done extensive field-testing on masonry heaters, now recommends that masonry heaters by accepted as a class of appliances, for use in vulnerable airsheds, as a "best available control measure (B.A.C.M.)." However, many jurisdictions are wanting each individual heater design to prove itself, as was required with woodstoves. By undergoing an E.P.A.-audited field test, and demonstrating compliance to construction standards that eliminate masonry fireplaces, masonry heaters that emit less than 6.0 grams of particulate (PM10) per kilogram of wood burned will receive an approval and be included on the Colorado-approved list. This procedure will ensure approval for masonry heaters which are equivalent or better than E.P.A.-certified stoves. E.P.A. field testing established that E.P.A. Phase II non-catalytic woodstove emissions averaged 7.3 grams per kilogram, while masonry heaters average only 2.8 grams per kilogram.

On April 21, 1994, by a vote of 6 to 2, the Colorado Air Quality Control Commission voted to include this new approval procedure. Following a signing by the attorney general this month and publishing in the Colorado register on June 10, this new ammendment will become effective June 30. Not all jurisdiction in Colorado are affected by this regulation, and many of those that are affected will have to create their own language to accept the masonry heaters approved by the State, for installation in homes. However, the MHA is committed to working with manufacturers, local dealers and customers to see that all the required procedures are followed.

Now, Coloradans who have only been able to select metal stoves, can soon pick from a large selection of mostly site-built masonry stove, as well. These heaters, while generally more expensive, provide a durable, clean alternative, with a high quality of continuous radiant heating. As regulators in vulnerable airsheds throughout the West look for better ways of controlling pollution, they will now have a procedure for allowing only the cleanest burning cordwoo-fueled appliances, thereby reducing air pollution and improving the quality of life for their jurisdictions.

For more information, or a copy of the new regulation, contact the Masonry Heater Association, 11490 Commerce Park Drive, Suite 300, Reston Virginia 22091.

BRITISH COLUMBIA TO REGULATE WOODSTOVES

Date: **March 16, 1994**

To: Stakeholders

From: Air Resources Branch, BC Environment

Re: Consultation on Wood Stove Regulation

As part of the Clean Air Strategy and in response to recommendations contained in "Smoke Management for the 90's", BC Environment is developing a regulation for new wood stoves. The ministry is seeking your assistance in ensuring that such a regulation will be as conprehensive and effective as possible.

The draft regulation has been prepared with input from a government/industry working group and is based on the Canadian Standards Association (CSA) B415.1 standards which were issued in 1992 and ammended in June 1993. The CSA standards are essentially the same as the phase II US EPA standards which came into effect on July 1, 1990, in the United States. These standards set particulate emission limits for various types of wood burning appliances (see attached "Reference Information...") and establish laboratory testing methods and procedures to classify certain classes of these appliances at the manufacturing stage. It is important to note that many manufacturers in BC are already meeting these standards.

Please find enclosed a copy of the draft regulation for your review. We would appreciate receiving your written comments by April 29,1994. Your submission should be sent to:

Bob Beaty
BC Environment
Air Resources Branch
2nd Floor, 777 Broughton Street
Victoria, BC V8V 1X5

If you have any questions regarding the above, please contact either myself at 387-4772 or Bob Beaty at 387-9946.

Yours truly,

Jackie Hamilton
Manager, Air Technology
Air Resources Branch

From the draft regulation:

...

Exemptions

2. (1) This regulation does not apply to central heating systems, site-built fireplaces, decorative (open) fireplaces, masonry heaters, cookstoves, and devices with a minimum burn rate above 5.0 kg/h;

4. Emission Requirements
4.1 Particulate Emissions
4.1.2

The average pariculate emission rate, as determined in Clause 10.9, shall be equal to or less than:

(a) for an appliance not equipped with a catalytic combustor:
  (i) 7.5 g/h for appliances with a maximum burn rate at or below 5.3 kg/h; or
  (ii) the greater of 7.5 g/h or 0.137 g/MJ (output) for appliances with a maximum burn rate > 5.3 kg/h

Date: **March 29, 2008**

To: Bob Beatty, BC Environment

From: N. Senf, Masonry Heater Association

Dear Mr. Beatty:

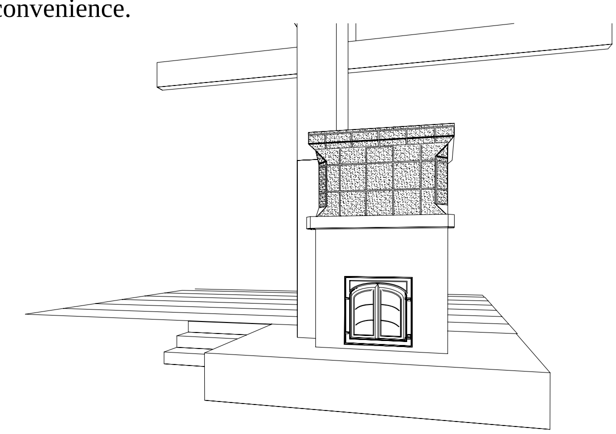
As an Associate of CSA B-415 technical committee, I recently received a copy of your office's "Memorandum re. Consultation on Draft Wood Stove Regulation", dated March 16, 1994. I would like to make several comments regarding the status of masonry heaters in your draft regulation.

It is noted that your approach parallels that of the EPA Phase II Rule in that it has a burn rate exclusion. It also excludes masonry heaters specifically, wheras EPA excluded appliances with a mass over 800 kg. I would like to relate our industry's experience with the U.S. regulations so far, in the hopes that this may help B.C. to address several unforeseen issues that have emerged from the EPA approach.

Our industry was initially pleased to be excluded from EPA. The EPA rule itself notes that masonry heaters are likely to be clean burning by virtue of their principle of operation, ie., the ability to store heat, which allows rapid combustion with a liberal air supply and the consequent elimination of smoldering combustion from the burn cycle. An additional complication would have been that the EPA test method for woodstoves does not lend itself to high mass appliances because it requires the determination of burn rate by placing the appliance on a scale during combustion. Finally, masonry heaters are typically site-assembled and would be unfairly restricted by test methods designed for mass-produced appliances that are required to operate under smoldering conditions.

Unfortunately, when the time came for the U.S. Clean Air Act to be implemented at the state and local levels, it became very convenient to mandate "EPA certified appliances only", as a means to achieve compliance. Masonry heaters were thus excluded by default. In Canada, we have faced this situation already with R-2000, which mandated EPA-certified appliances only, in 1993. Ironically, this was not even done to address emissions, but air consumption instead. The EPA standard was used as a surrogate for lack of anything else. Again, masonry heaters fell through the cracks. Our industry, which is very small, has thus been forced to invest a great deal of time, energy and money to address these issues over the last several years. Among other things, OMNI Environmental conducted EPA-audited field tests of a representative sample of commercially available masonry heaters, and these results have been accepted by EPA in their AP-42 document. The average of all field tests for Phase II non-cat woodstoves was 7.3 g/kg and for all field tests of masonry heaters was 2.8 g/kg. Enclosed please find a paper that provides further background on these issues.

Although as an industry we are pleased to be mentioned by name for exclusion from B.C.'s proposed regulation, we would ask that consideration be given to addressing the issues that have resulted from a similar experience in the U.S. Namely, we would ask that masonry heaters be granted recognition as a clean-burning technology that is "equivalent to EPA-certified", based on the documentation that is cited in the enclosed paper, "Recent Laboratory and Field Testing of Masonry Heater and Masonry Fireplace Emissions". Experience has shown that this approach may require additional consideration, for example, masonry heater definition. Our association has developed a considerable body of work in these areas, and would be pleased to discuss these issues in detail with you at your convenience.



Modular Core With Custom New Alberene Soapstone Facing

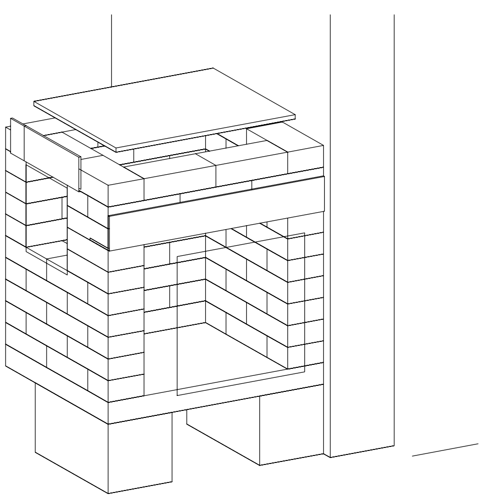
R2000 DISCUSSION HEATS UP

(Continued From Page 1)

computer hardware almost instant access to discussions such as these. It would also inform the discussions with a broader range of views and experience - some of you have been building heaters for fifteen years and more, and pooling our knowledge is really what keeps MHA rolling.

It also highlights a very practical problem that E-mail would solve. During the thick of the discussions below, in order not to leave anybody out, there were times when 10 pages of information needed to be faxed to 15 different parties. Two hours of time, plus 15 long distance calls - not very practical, much less so as the discussion expands. With E-mail, your computer makes a local phone call to a service provider such as Compuserve, uploads your outgoing messages to an unlimited number of people anywhere in the world, downloads your incoming messages - all at the press of a button. There's only one catch - you have to learn how to type. (See E-mail article on page 40).

The easiest way to present the current R2000 discussion is to let it speak for itself. The documents below have been edited for length and also because some comments and opinions weren't intended for distribution. This article has been sent for review to the originating parties. There doesn't appear to be a clear consensus on a couple of issues. This may be a sign of the times with increasing participation by manufacturers. Your views are important, and your dues buy you a vote, so fax or write MHA News.



February 18, 1994
From: N. Senf
To:
Rick Crooks
Tom Hamlin (R2000/NRCan/CANMET)
John Broniek (R2000 Co-Ordinator, Canadian Homebuilder's Association (CHBA))
Skip Hayden (Combustion and Carbonization Research Lab (CCRL)/CANMET)
Don Fugler (Research Division, CMHC)
John Lagamba (Tempcast)

During Heikki Hyytiainen's recent visit, we arranged a meeting on Dec. 20/93 at CMHC and the opportunity arose to piggyback an R2000 meeting, attended by: Heikki, myself, John Broniek, Robin Sinha (NRCan/CANMET), Tom Hamlin, Skip Hayden, Don Fugler, Oliver Drerup (CMHC), and Gary Sharp (NRCan/R2000). A wide range of issues was discussed. At the end of the meeting, Robin Sinha presented a discussion paper on research proposals that arose out of separate discussions that had been taking place with Tempcast and Crossfire.

> A NUMBER OF ISSUES WERE DISCUSSED AT THE CCRL MEETING, AND I BELIEVE THAT A CONSENSUS OF SORTS WAS REACHED ON SEVERAL

Previous to this, John Lagamba and I had a telephone discussion on the certification issue. I seems likely that the MHA professional stovemasons and the manufacturers may have some separate interests in this regard. I suggested to John that he express his viewpoint and concerns to John Broniek, and a subsequent letter from Tempcast was tabled at the meeting. *(ed note: see below)*

Tom Hamlin has since taken over Robin's role. Tom called a meeting at CCRL on Feb. 5, attended by Skip Hayden, Ron Braaten (CCRL), Tom, John Broniek, Ross Monsour (IRAP, Industrial Research Assistance Program) and myself.

A number of issues were discussed at the CCRL meeting, and I believe that a consensus of sorts was reached on several, outlined below. Due to time constraints, there hasn't been any discussion yet with MHA members, including Canadian manufacturers. However, these issues will be on the table in Reno so that the membership at large can be heard and participate in the decision process. Although these happen to be Canadian issues right now, there is quite a bit of overlap with current events in Colorado. How we deal with them will establish important precedents. R2000 is probably as benign as it's going to get, so we should make the most of the opportunity.

Without getting into a background discussion, here's a dry run at an R2000 proposal:

ASSURANCE OF NO STARTUP SPILLAGE:

- Bypass damper required for downdrafting systems.
- No outside chimneys allowed.
- Heater shall not penetrate the envelope (exterior walls).

ASSURANCE THAT THE HEATER WON'T/CAN'T BE USED AS AN OPEN FIREPLACE:

- 200x200 flue liners max (masonry chimneys).
- Max metal chimney size: (?)
- Max bypass damper size 100x100.

ASSURANCE THAT HEATER CONSUMES LESS THAN 30 L/SEC ROOM AIR

THIS IS QUITE A SHOPPING LIST, AND SOME OF IT WILL ALMOST CERTAINLY BE CONTROVERSIAL

(ie., no outdoor air supply required, the same as EPA stoves now included)

- No underfire air.
- Current HTIP project (Masonry Stove Builders) to provide field data.
- Additional independent field test(s) of existing heaters in R2000 houses (NRCan and CHBA).

Note: since masonry heaters are currently built under the Building Code, no outside air would violate code - nobody has addressed this.

ASSURANCE THAT MASONRY HEATER IS IN FACT A TRUE MASONRY HEATER

- Certification by installer and registration with MHA (see below)
- Accept draft ASTM masonry heater definition

Note: MHA is currently proposing a more strict definition for Colorado.

ASSURANCE THAT MASONRY HEATER HAS LOW EMISSIONS AND ACCEPTABLE EFFICIENCY.

- Certified heaters (see below)
- No underfire air
- Testing by CCRL of existing old Tempcast underfire unit in their lab as a "generic heater" before/after an overfire air retrofit (Note: this takes about 10 seconds). Funding from CHBA and NRCan.
- MHA support of generic research to generate air design and fueling guidelines (Lopez Labs ?).

QUALITY ASSURANCE/CERTIFICATION

- Installer shall be certified (see below)
- All R2000 heaters shall be certified by installer that they are registered with MHA. MHA will design a data form to be completed by installer and will set up and maintain a registry of masonry heaters installed in R2000 houses. This establishes a feedback mechanism and database to help identify any problems occurring with installations and prevent recurrence.
- Heater installer shall be WETT certified and have his/her trade certification as a mason (either interprovincial or in the province of the installation).
- Alternatively, heater installer shall be certified by MHA when MHA has developed a certification program.

BYPASS DAMPERS

- Shall be clearly labelled
- To prevent damage to flue liners, there shall be 4 feet of refractory liner ("Refratco" or equivalent) past the point where the bypass connects to the chimney.

METAL CHIMNEYS:(?)

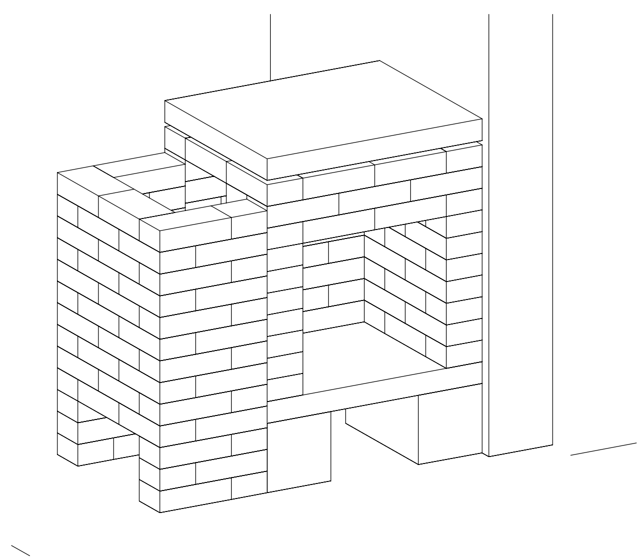
CHIMNEY DAMPERS

- Shall be clearly labelled
- CO alarm shall be installed (hardwired or battery ?)

MISCELLANEOUS:

- Develop a standard vapour barrier detail for penetration of chimney through envelope
- Adopt ASTM standard (when passed)

This is quite a shopping list, and some of it will almost certainly be controversial. We need to get it on the table, however, particularly with the Reno meeting coming up. I believe that these proposals were arrived at in good faith and deserve to be discussed on their merits by the membership. MHA bylaws ensure that there will be a quorum for the annual meeting, giving us an opportunity to officially endorse those provisions on which we can establish consensus.



(The following letter is referred to above)

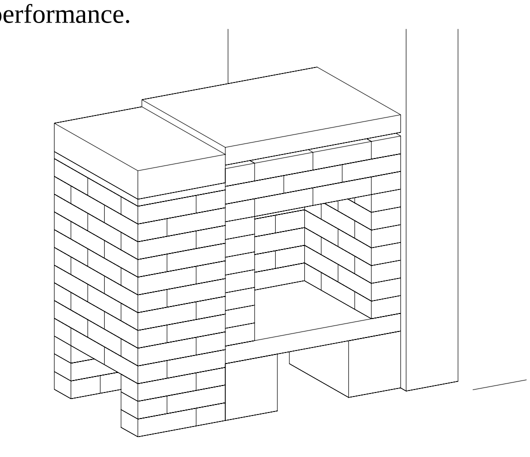
Dec. 20, 1993
To: John Broniek, CHBA
From: John Lagamba, Tempcast
Copies to: Norbert Senf

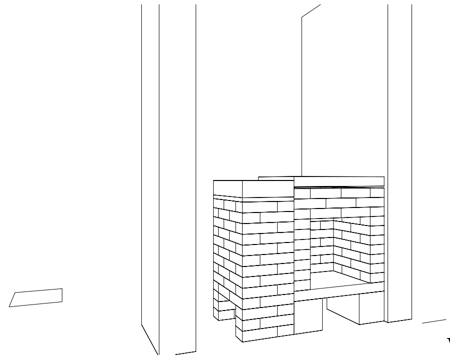
As members of MHA, we are pleased with the executive's efforts to bring our concerns to your attention. However, we find it important to give you an alternate perspective, from our unique position as a manufacturer.

Tempcast is a Canadian owned manufacturer of modular masonry heaters. We are one of the 3 largest manufacturers of masonry heaters in North America, and by far the largest in Canada. Temp-Cast heaters have been in the marketplace for five years and approximately 800 have been sold and installed in North America. In this time, we have had no significant field problems with either installation or performance.

Our comprehensive Planning Guide, Installation Manual and Installation Video ensure proper installation. Our Owners Manual and customer support ensures that the consumer can confidently operate the heater for maximum safety and performance

Temp-Cast heaters are constructed from a fully modularized core. We also control the manufacture of the cast iron doors and grates. Our comprehensive Planning Guide, Installation Manual and Installation Video ensure proper installation. Our Owners Manual and customer support ensures that the consumer can confidently operate the heater for maximum safety and performance.





What sets us apart from hand-built masonry heaters, is of course, the fully modular design. The significance of this is critical and points to the Achilles heel of hand-built and partially hand-built heaters. We realized at the outset that the installer would be the major obstacle to wider distribution of the masonry heater concept. With a hand-built unit, everything depends on the installer. His experience, skill and attention to detail determines whether the heater will work properly, if it will draw properly and if it will be safe, as the majority of hand-built units are. Unfortunately, defective hand-built heaters are not uncommon. It is for precisely this reason that MHA is advocating certified heater masons, and we support this position in regards to hand-built or partially hand-built heaters. However, we also realized that the level of training needed to consistently design and build a quality masonry heater was such a large undertaking, that the masonry heater industry was doomed to relative obscurity for many years. We believe that well designed custom built masonry heaters will always be in demand, once the issue of proper training has been resolved. (MHA has been attempting to address these issues since at least 1987, which has been a slow process due to the number of masonry heater styles, and the diversity of the individual, strong-minded craftsmen.)

In order to eliminate the mason as the weak link in the process, we developed a product that removes from him the responsibility for correct design and proper construction of the heart of the heater, the core. We give him a precise product based on the simplest and arguably the most efficient design, and he only has to do what he can be easily shown and already knows - assemble the core and enclose it in locally available masonry materials. The product is shipped complete to the site, and by following the video and manual, a mason who has never seen it before can install it correctly. This approach has proved successful across North America.

We feel that the requirement for EPA certification for wood-burning appliances in R2000 homes must be ammended to allow masonry heaters.

Ideally, the R2000 program will include masonry heaters of both varieties - those that are custom-built by specially trained and certified masons and those that, like the Temp-Cast, don't require specially trained masons.

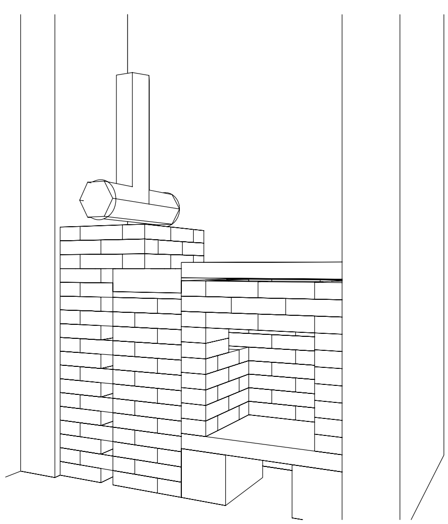
March 8, 1994
To: Norbert Senf
From: Tom Hamlin (CANMET, Buildings Group)
Copies to: Don Fugler, Skip Hayden, John Broniek, John Lagamba, John Steele (Crossfire)

Attached is the latest draft of requirements for masonry heaters in R2000 houses as discussed at the CANMET lab at Bell's Corners last month. Please circulate these requirements among members of your industry for comment. Please provide any pertinent data that can be used to substantiate these requirements.

The current proposed work should involve testing of the masonry heater at CANMET with and without an underfire grate with emissions and efficiency measurements. A number of R2000 houses in the Ottawa area will also be tested with a grate removal retrofit and some indicators of performance measured as well if possible. The data from CMHC/MHA's project should be useful to substantiate combustion air flow and airtightness of doors.

R2000 WOULD PREFER THAT REPONSES CAME THROUGH YOUR ASSOCIATION AS THE INDUSTRY NEEDS A COMMON FRONT IN ORDER TO PROCEED EFFECTIVELY ON THE ACCEPTANCE OF THIS TYPE OF HEATING APPLIANCE

This letter and attachment is being distributed to you and other members of the industry. I would prefer that reponses came through your association as the industry needs a common front in order to proceed effectively on the acceptance of this type of heating appliance.



Masonry Wood Heaters

Masonry Wood Heaters having the following characteristics are being evaluated for emissions, indoor air quality and energy efficiency. They are expected to be equivalent to or better than the EPA certified wood stoves and would therefore be so recognized by the R2000 program.

- no firebox grate, top burning designs only, no bottom air inlets to firebox.
- confirming to ASTM Standard Guide for the Construction of Solid Fuel Burning Masonry Heaters E6.57.07. Clause 3.2.18 describes a Masonry Heater as follows: a vented heating system of predominantly masonry construction having a mass of at least 1,764 lbs. (800 kg) excluding chimney and heater base, in particular, a unit designed specifically to (1) enable a charge of solid fuel mixed with an adequate amount of air to burn rapidly and more completely at high temperature in order to reduce emissions of unburned hydrocarbons and (2) to capture and store a substantial portion of the resulting heat energy in the mass of the appliance through internal heat exchange flue channels, and (3) to gradually release the stored energy to the space to be heated.
- firebox doors must have air leakage rates of 20 L/sec or less at 25 Pa when tested by the method included in ULC-S638M (?).
- combustion air supply as per local codes or as per CSA B415.
- chimney and heater must not be installed on a wall exposed to an unheated space.
- interior chimney size shall be nominal 8" by 8" or less cross sectional area, or as recommended by manufacturer.
- basement installation is not recommended, however should basement installation be specified, bypass damper must be provided and at least 1 m of refractory liner provided after the damper.
- all dampers and doors shall be permanently labelled so as to indicate their proper position during operation.
- must have a CO alarm in the room (battery or 115 VAC operated)
- all units shall be installed by personnel designated by the manufacturer of a modular unit or by qualified masons having also taken the Wood Energy Technical Training (WETT) course.

March 22, 1994

To: Tom Hamlin (CANMET, Buildings Group)

From: Norbert Senf

Copies to: (including a copy of Mar. 8 letter from Tom Hamlin) Pat Manley, Ron Pihl, Tina Subasic, Lou Frisch, John Broniek, Don Fugler, Skip Hayden, John Lagamba, John Steele, Jack West (TULIKIVI), Heinz Flurer (Biofire), Tom Stroud (Envirotech), Stig Karlberg (Royal Crown), Jerry Frisch (Frisch-Rosin)

I received a copy of your March 8 letter outlining the draft requirements for masonry heaters in R2000 houses. Also, I’ve since had the opportunity to present my February 18 proposal for discussion at the recent MHA annual meeting in Reno.

Most of the requirements that are in your March 8 document did not meet any opposition at the MHA meeting. However, there were some serious objections

THE TWO ITEMS WHICH WERE OPPOSED BY MANUFACTURERS WERE THE 8X8 FLUE REQUIREMENT AND THE BYPASS DAMPER REQUIREMENT

from several manufacturers on two items. As well, a manufacturer of heaters with underfire air wanted to be on record as opposing the overfire air requirement. The CO alarm was considered acceptable provided that it did not single out masonry heaters and make them appear dangerous, but instead was made a requirement for EPA certified appliances as well.

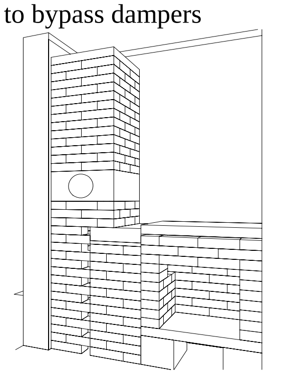
The two items which were opposed by manufacturers were the 8x8 flue requirement and the bypass damper requirement.

•8x8 Flue Requirement *(ed. note: this had already been modified in the above draft, so this discussion has been edited out)*

•Bypass Damper Requirement

- there is insufficient or no evidence to require the use of bypass dampers

- this would pose a hardship to manufacturers whose units are not easily adapted to bypass dampers



- this would be an unfair restriction of trade since the same requirement is not imposed on EPA ceritified appliances.

Recommendations:

I would like to make the following recommendations, with the proviso that MHA's endorsement is contingent upon review and approval by members of our executive.

•8x8 Flue (deleted)

•Bypass Damper

A compromise might be to restrict the proposed requirement for bypass dampers in basement installations to units that are custom-built. For manufactured units the recommendations of the manufacturer would be followed. Although installing bypass dampers is, in my view, not a problem with basement contraflow heaters, there would certainly be significant problems for manufacturers of other heater types.

•Installer Qualification

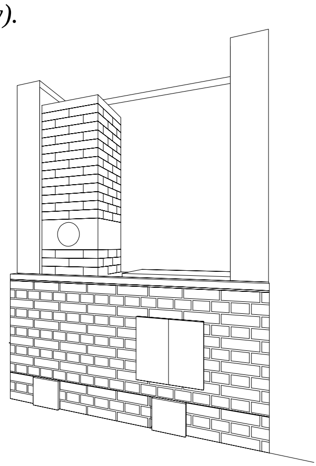
There was a serious commitment made at this year's MHA meeting to proceed with the development of a training program for builders of custom heaters. Although this is a long-term project that will take several years to achieve, it would be useful to leave the door open for MHA (or equivalent) training, once it becomes available, as a requirement for custom built units.

March 23, 1994

To: Norbert Senf

From: Heinz Flurer (Biofire)

Thank you for the faxes. The rewrite looks good. The only question that I have concerns the testing of firebox doors for leakage. Is this part of the testing that you have already done or would there be additional testing required? *(ed note: see below).*



Custom Designed Utility Heater with Cooktop to Fit Existing Alcove and Chimney

March 24, 1994

To: Norbert Senf

From: Tom Stroud (EnviroTech)

Copies to: Walter Moberg (Moberg-Royal Crown), Stig Karlberg, Rick Crooks, John Lagamba, Pat Manley

R2000 should not mandate aspects of heater construction but rather should mandate levels of emissions. This is the approach that EPA takes. They do no say, for example, you must produce only pellet stoves, or only catalytic stoves. They state that you must have emission levels that lower the PM output, period. It is up to manufacturers and custom builders to determine how they will accomplish that. I also am not sure what a top burner is. We have always referred to our firebox geometry as being a base fired unit as opposed to an under-fire unit. I think these terms are more descriptive and would lead to less confusion.

THE WHOLE ISSUE OF BYPASS DAMPERS ASSUMES THAT THERE IS ONLY ONE ACCEPTED METHOD OF CONSTRUCTION OF A MASONRY HEATER

I have no problem with the acceptance of this definition, but feel that the definition that has been hammered out between MHA and the Denver Air Quality people is a much more restrictive and useful definition. This was accomplished by Walter Moberg with much help from Paul Tiegs of OMNI Environmental Services and Rick Crooks, as well as the legislative committee of MHA.

How will door leakage be measured? Will this be a laboratory test on a door or on an installed door in a heater? Is this leakage rate based on an opened or close air intake door? Is this an expensive or an inexpensive test? Is this in accordance with what the EPA stoves will be expected to meet?

What are the local codes pertaining to combustion air? Will masonry heaters be required to have outside air to the firebox in some municipalities and not in others? What does CSA B415 demand? Out units utilize makeup air for combustion that must be connected to the unit, but not into the firebox. Will that type of installation be acceptable?

On this point does this mean that a wall of the heater cannot be exposed to an unheated area or does it mean you cannot place a heater on an outside wall, yet in the envelope of the home (See following diagram). To our company that seems a bit restrictive and unnecessary. At the meeting in Reno you mentioned the restriction against outside chimneys, which seems a bit extreme. Not allowing it to be installed against an outside wall seems unnecessarily restrictive and does not serve any purpose.

Again this code should not determine how heaters are to be built, but make demands on results only.

The whole issue of bypass dampers assumes that there is only one accepted method of construction of a masonry heater. They need to tell us what results they seek, not how to accomplish it. All a bypass damper would create for most systems is the opposite of what they seek. It gives people the capability of using them as fireplaces. Why legislate refractory lining in a chimney? Why not legislate that the heater never have temperatures above 350 or 500F at the connection to the chimney.

We have no problems with labelling dampers and doors. I certainly would hope that this is demanded of EPA certified units.

We disagree with AC powered CO detectors because many people put their wood burning appliances through extremes when there are power outages and you stand the chance of CO poisoning in those situations. We also feel that all houses that heat with combustion units (gas, oil, wood) should have CO detectors, not just masonry heaters.

Our position remains the same as far as designated installers for manufactured units. Our unit has been designed to be installed by anyone with masonry skills. It was designed that way and has proven itself over the period of time we have been offering our EnviroTech units.

In response to your letter, I have several comments. I am in agreement with your letter up to the section called RECOMMENDATIONS. To approach CANMET on a unified front there should be no "I" statements. The statements should all be "we" statements and they should have the endorsement of the association before they are ever presented to someone outside the association.

•8x8 Flue *(deleted*)

•Bypass Damper

This whole issue is a moot point. They only relate to one manner of construction and mean nothing to the other construction methods. ASTM lists four standard styles of masonry heaters, only one of which uses a bypass damper. This regulation limits methods of construction and should not be a part of any regulation about masonry heaters. Statements relating to personal views do not have any place in a letter representing the industry.

I appreciate all that you have done to bring us to this point with R2000. My concern is that we as an association should represent a unified front to this type of group.

March 25, 1994
To: Tom Stroud (EnviroTech)
From: Norbert Senf
Copies to: MHA executive

First of all, I must apologize for not giving you adequate chance to comment. Tom Hamlin's March 8 letter only reached me on March 22, since I neglected to leave Tom a Seattle fax number where I could be reached. I felt a need to draft a response to Tom sooner rather that later, in view of the Reno discussion and since we're testing at Lopez for the next two weeks without any breaks.

From my Reno notes it seemed that there were only two main disputed issues that made it into R2000's proposal. The two that were left (8x8 flues, bypass dampers) were, or could be, watered down. On underfire air, I believe we are talking air through a grate in the firebox floor.

> INTEGRATE MASONRY HEATING SYSTEMS INTO FUTURE HOUSING STANDARDS, BASED ON SOUND THEORY AND RESEARCH

It is a point well taken that any new regulations form important precedents. Again, R2000 is a voluntary performance standard that has had the result of advancing housing technology in Canada and has been the showcase for a number of new energy technologies. My experience with it over 10 years has been on a very co-operative basis, and changing to the more adversarial approach that we are too familiar with in some areas is, in my opinion, a dead end. It is not my impression that the idea here is to get R2000 off our back. Rather, we would like to integrate masonry heating systems into future housing standards, based on sound theory and research and in a way that benefits all stakeholders.

It is important to try and understand the particular issues of concern to R2000. These were outlined by John Broniek in the Spring 93 issue of MHA News. In particular, emissions are not the issue here. EPA ceritification was merely used as a surrogate for an air consumption standard. This was negotiated with the Canadian Wood Energy Institute, and the masonry heating industry was not at the table. The main issue is the potential for the masonry heating system to cause house depressurization and consequent startup spillage in gas and oil furnaces. The second issue is certification of the masonry heater installation and its integration into the house aerodynamics.

I'm happy to report that it looks like door leakage is a non-issue. The draft CMHC report *(ed note: this report is printed elsewhere in this issue)* that was distributed in Reno indicates that the draft ULC fireplace door standard

(ULC-S638M) is way off base. They are calling for under 28 L/sec at 25 Pa and our testing showed all masonry heater doors tested, even “leaky” old ungastketed doors, to be under 6 L/sec. Bets are that the ULC standard just isn’t going to fly.

The outside wall issue is still a bit fuzzy as well. My understanding is that you can’t penetrate the envelope, ie., as with a traditional outside wall masonry fireplace. There should be no problem with the setup you sketched (4” airspace between heater and interior surface of an outside insulated wall).

•Outside chimneys

I don’t agree with you, for a variety of reasons. Basically it just is not good building science.

•On bypass dampers, we are talking basement installations only, ie., the part of the house with the highest negative pressure, due to stack effect. I have personally seen, and also spoken with numerous professionals and users who have seen, startup spillage problems with basement fireplaces, heaters, stoves and furnaces. CMHC has published very extensive research on this, to which I would refer you. Again, good building science. Blaming the chimney just doesn’t cut it. A bypass is an easy fix for a heater that has any downdrafting flue runs. I’m proposing to keep manufactured heaters such as the EnviroTech out of this. I have yet to hear an argument against from a custom builder.

•I don’t see how you could legislate and enforce exit temperatures of a heater, particularly the bypass exit on a contraflow. Your point about refractory liners is well taken. It is probably only specific to contraflow heaters. An EnviroTech obviously wouldn’t need it if only the downdrafting channels were bypassed, rather than bypassing through the firebox ceiling.

•CO detectors

The R2000 proposal states battery/AC, its your choice. Cordwood burning devices have a higher need for this because of the high CO phase typical of the tail end of the burn, something not shared with gas, oil, or pellets.

•Your position on designated installers does not appear to differ from the R2000 proposal.

Again, my apologies for not being organized enough to send this around for several rounds of comment. I did push to get it on the agenda in Reno, but it was at the end of two long days and we certainly could have used more time. One solution in future would be to get our proposed E-mail network up and running. Sending out 90 pages of faxes takes a couple of hours each time. We might also want to thing about running more or concurrent technical sessions at the MHA meetings, since I’ve gotten strong feedback from Heater masons that this is what they are most interested in.

March 28, 1994
To: Tom Stroud
From: John Lagamba
Copies to: Pat Manley, Tina Subasic, Jerry Frisch, Walter Moberg, Norbert Senf, Jack West, Heinz Flurer
(Included is March 8 letter from CANMET)

Their concerns appear much less *regulating* that we expected. Unfortunately, I did not have this most recent letter for our meeting in Reno. I would like to propose that we treat my response to Tom Hamlin as a draft, for comment.

(Excerpt from draft letter to Tom Hamlin):
(Comments on underfire air, flue sizing)
•Bypass Dampers

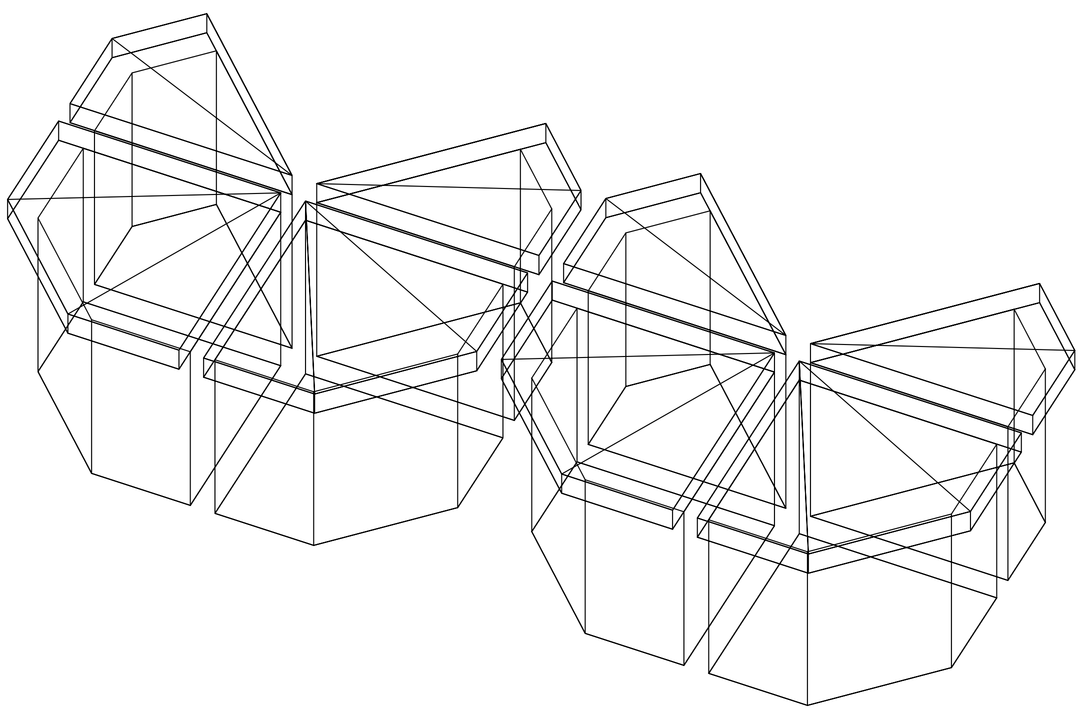
> WHERE A NEGATIVE PRESSURE SITUATION EXISTS, SOME SPILLAGE MAY BE INEVITABLE, WHETHER THE APPLIANCE IS A MAOSNRY HEATER OR A METAL WOOD STOVE, WITH A BYPASS DAMPER OR NOT

Our experience (and that of others in the masonry heater industry) is that the benefits of bypass dampers are outweighed by their shortcomings. To begin with a bypass damper allows a homeowner to operate their heater as a fireplace, by sending the heat directly up the flue. Many broke in use because of the extreme temperatures experienced at their point of installation - usually approaching 2000 degrees F. Many that did not break became jammed. It is our experience that all bypass dampers carry the potential for abuse by the operator, in which the doors are closed and the damper is left open. In this situation, unacceptably high chimney temperatures can result, which may pose a safety problem. In our opinion, the additional requirement for using refractory liners is not feasible because they are not readily available across Canada. In addition, we are not convinced that bypass dampers for basement installations would completely eliminate the possibility of cold-start spillage. (This is not a requirement for the installation of an EPA certified stove). Where a negative pressure situation exists, some spillage may be inevitable, whether the appliance is a maosnry heater or a metal wood stove, with a bypass damper or not. We find it more reliable, safer and more effective to educate the homeowner, so that he is alert to the potential of cold-start spillage.

•CO Alarm

This is a well-intentioned but premature proposal. We understand that CO alarms are not yet available across the country and may not be available universally for at least a year. We have learned from one of the largest distributors (American Sensor) of these products that the first generation of these alarms were found with a serious design flaw and have been pulled from the shelves. Our proposal would be to encourage the homeowner to obtain one as soon as they are on the market. Does the R2000 program require EPA woodstoves to be installed with a CO alarm now.

We view the other proposals contained in your letter feasible and sensible.



March 30, 1994
To: Norbert Senf
From: John Lagamba (Tempcast Enviroheat)

•Re. bypass damper installations.

I don't think you can separate hand built from manufactured units. If we present a case where bypass is the solution to negative pressure caused by stack effect, it would only follow, that it be common to all units. Additionally, as discussed in Reno some units and some designs do not lend themselves to a bypass.

(Comments on underfire air, deleted)

March 31, 1994
To: John Lagamba
From: Norbert Senf
Copies to: MHA executive

> CURRENT MASONRY FIREPLACE AND CHIMNEY CODES ARE BASED ON HISTORICAL PRACTICE, AND WITH THE RECENT ADVENT OF... HIGH PERFORMANCE HOUSING STANDARDS, A NEW APPROACH IS NEEDED, ONE BASED ON SOUND BUILDING THEORY AND PRACTICE

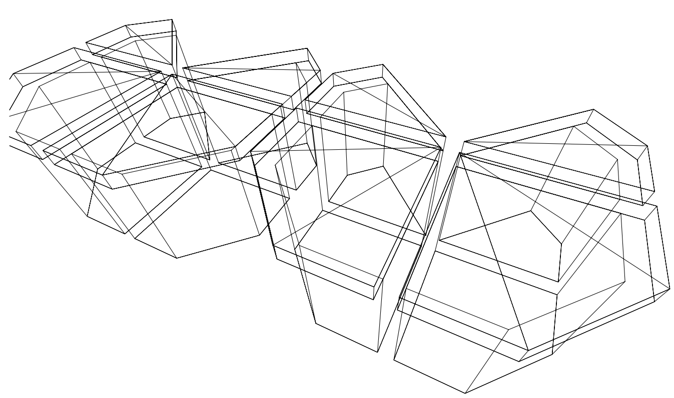
(Comments on underfire air, deleted)

Air consumption is very germane to the R2000 discussion. The goal ultimately is to get the outside air requirement dropped from the building code, since it has no demonstrated or theoretical benefit. This can never happen as long as underfire air heaters are included *(ed. based on air consumption data in CMHC report*). Actual research in this area had never been done until recently, and Tempcast deserves credit for supporting this work. This leads to a second point: current masonry fireplace and chimney codes are based on historical practice, and with the recent advent of airtight, mechanically ventilated, high performance housing standards, a new approach is needed, one based on sound building theory and practice.

I disagree with your statement *(regarding underfire air*) that "refinements and improvements will follow naturally in a competitive marketplace". The record shows that stove manufacturers did not start the expensive process of developing clean-burning designs until they were forced to by legislation. Their first priority, of course, is to sell stoves and generate a profit. In many cases this used to translate into keeping the price as low as possible, with predictable results. Society at large was left to pick up the tab for the environmental consequences.

•Chimney size: flue sizes larger than 8" id round or 8x12 modular have no place in an R2000 house, in my opinion. This is very easy to demonstrate with a WOODSIM computer simulation (*ed note: see Spring 93 MHA News, p. 6*). One concern raised by R2000 is the inevitability of appliances that are essentially fireplaces trying to "sneak in" under the masonry heater rules. I am not aware of any masonry heater with a flue requirement larger than modular 8x12 (65 sq. in). The TESS was an interesting case in point. In our ASTM discussions at the time, there was a clear consensus that this was not a masonry heater. The issue will no doubt resurface and make for interesting discussions at future MHA meetings.

•Bypass Dampers: we're proposing to limit the size of the bypass to 4x4" specifically to address the concerns that you raised. I've witnessed a number of incidents, albeit infrequent, of basement startup spillage in downdrafting heaters that was essentially irreversible due to the lack of a means to get energy directly to the flue without having to go through a downdrafting heat exchanger. It should also be pointed out that in Finland a bypass damper is a standard item that is available at the hardware store. On the Grundofen side, the "Anheitzklappe", or warm-up damper, is a standard item in Germany, Austria and Switzerland. Since these appliances are essentially unknown in North America, we cannot expect too much of Mr./Mrs. Public, particularly if he/she has acquired the heater through a resale of the house. We're probably at an impasse here, since, lacking any objective data, we are having to resort to opinions and anecdotal experience only. I would note that on the chimney side of the equation, there is a substantial body of recent Canadian research to document the widespread existence of startup spillage in basement combustion appliances.



April 30, 1994
To: Norbert Senf
From: John Lagamba
Copies to: MHA Executive

Please excuse the delay in responding to your fax of March 31, due to the National Home Show and the unexpected relocation of our sales office to Toronto.

Your letter raises several concerns:

•In the interests of fairness, we should use air requirements and efficiency as criteria for approval rather than disallowing underfire air.

•Our concerns with bypass dampers is finding units that will not seize and will function for the life of the heater. They also have a limited usefulness, in that they will not prevent all spillage problems related to “stack effect” and negative pressure induced draft reversal. They will only be useful for combating a cold chimney situation, which we feel has been adequately addressed by our airtight door system. Bypass dampers must not be promoted as the saviour of all smoke spillage and cold-start problems.

BYPASS DAMPERS MUST NOT BE PROMOTED AS THE SAVIOUR OF ALL SMOKE SPILLAGE AND COLD-START PROBLEMS.

•I agree with your assessment that clean-burning designs were not an industry initiative and that the wood stove industry’s first priority was to “sell more stoves and make a profit”. Although I cannot disagree with the concept of making a profit, I believe our industry has shown a more responsible side. Had our industry not been “passion driven” (vs profit driven), I am certain that MHA would not have survived. Temp-Cast is proud to be part of this.

•Our strongest concern is with using generic test results for all masonry heaters. Those that are substantially the same as independently tested heaters would be acceptable to us. We will not permit a unit with a 25” wide firebox that consumes wood at the rate of 65 lbs/hr to “piggy-back” on the results of tested units without additional audited independent testing.

May 13, 1994
To: Norbert Senf
From: Tom Stroud

Our strongest objection, thus far, is a requirement for a bypass damper, in order to eliminate startup spillage. As a custom builder who has personally built several hundred stoves and as a manufacturer I disagree with that position. In the Grundofen construction method, the “Anheitzklappe” (preheat damper) is used only if it is to give a unit the capability of being used in a fireplace mode. It may be that it is being used otherwise, but I am not aware of that. Using the combination of tight doors and the “gas slot” in the top of the firebox, the Grundofen typically do no have startup spillage. The exception to that would be that of the initial firing of the unit, which we recommend take place before the house is closed in (finished). Most basement installations, because of their increased chimney heights, tend to draw better than units on higher stories. I think you are right about having difficulty solving this specific situation. We as a company will not support a decision to include recommendations for by-pass dampers in all units. If those who manufacture and build Contraflow Masonry Heaters want to impose that on themselves, this is up to those of you who build them.

I am quite aware of CMHC’s research and have used that research (*Fireplace Air Requirements*, which you supplied me) specifically in helping Washington State as well as the Bonneville Power Administration to allow the use of make-up air for Masonry Heaters, instead of direct connect air. CMHC’s findings absolutely confirm that direct connection of outside air to the firebox creates very negative effects. Our unit has been designed to have both outside air and makeup air even though we have strong reservation against directly connected outside air to the firebox.

I am still not in agreement with regulating exhaust flue size or the manner in which air is introduced to the firebox. Until we see emission and efficiency results, it is impossible to judge capabilities of units with larger flue sizes. The same goes for underfire air. I agree that underfire air apparently is not a good choice, but I also know that someone may come up with a way of cleaning that up. In many ways the Masonry Heater industry is in its infancy in North America. I don’t like seeing unnecessary restrictions based on the way we see the industry right now. Again, it comes down to what results can be produced. Regulate based on results, don’t try to figure out how one person or another thinks that those results can be produced.

I appreciate your persistence in keeping us informed and hope that you will continue. We do not do any custom building in Canada, but do export quite a number of EnviroTech Radiant Fireplaces into Canada, and have a great investment in how regulations are going there.

Editors note:*In an effort to wrap up this installment for the newsletter deadline, that will have to be the last comment.*

Stack Effect, Bypass Dampers and Chimneys

A Literature Review

The R2000 discussions in the previous article highlight a variety of issues of concern to the masonry heating industry and the regulatory community.

To inform this debate further we need, obviously, definitive research and literature. As a start, below is a brief survey of information taken from the MHA News library. The CMHC reports referred to are available from:

The Canadian Housing Information Centre - (613) 748-2312

BYPASS DAMPERS:

> Bypass dampers ... serve to shorten the heat exchange channel length and enhance the ability to establish draft (negative pressure) in the chimney

K. H. Pfesdorf, P. Eng., **“Lehrbuch Ortlicher Raumheizung 1**”, Verlag fur Bauwesen, Berlin, 1978, p. 127

“Bypass dampers (Anheitzklappe), when open, serve to shorten the heat exchange channel length and enhance the ability to establish draft (negative pressure) in the chimney. They are to be installed in such a manner that the gases cannot stream directly from the firebox into the chimney.

There are two types of bypass dampers, manual and semi-automatic. In semi-automatic dampers the opening is regulated by a temperature sensing mechanism.

Materials: Frame and damper plate from cast iron or heat resisting sheetmetal. Sheetmetal must be capable of withstanding a service temperature of 600 C with no adverse effects.

W. Hausler, P. Eng., **“Technisches Handbuch des Hausbrandes**”, Der Vereinigung Kantonal-Schweizerischer Feuerversicherungsanstalten, Bern, 1950, p. 92

“Sometimes (particularly with wood-fired units), the gas slot is replaced by a bypass channel (Kurzschlusskanal) with a damper arranged in such a way that it can only be opened when the firebox door is closed.”

MAKEUP AIR AND HOUSE DEPRESSURIZATION:

MHA members will find the following in their newsletter archives:

“**Testing House Pressure and Bringing in Outdoor Air**”, John Gulland, MHA News, Vol 6 No 2, p. 44

“**Canadian R2000 Program Shuts Out Masonry Heating Systems**”, MHA News, Vol 6 No 1, pp 1 - 3.

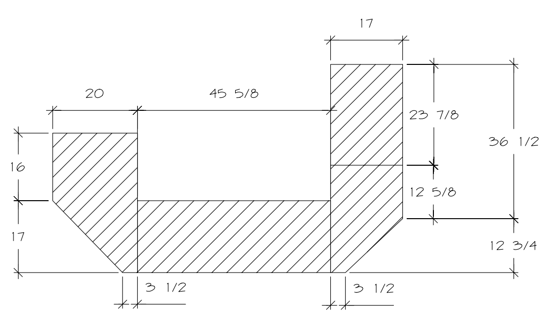
“**The Canadian R2000 Standard: The Future is Now**”, MHA News, Vol 6 No 1, pp 3 - 5.

“**Washington State Presents: The Depressurized House**!”, Norbert Senf, MHA News, Vol 4 No 3, p 3.

> The 8 x 12 fireplace has a flue flow of 150 L/s resulting in a 5 Pa (Pascal) house depressurization. The 16 x 16 fireplace results in a flue flow of 450 L/s and a 20 Pa house depressurization

“**Fireplace Simulator**”, Norbert Senf, MHA News, Vol 6 No 1, pp 6-7.

Two open fireplace simulation runs in a tight house under the same set of conditions (no makeup air) are described - one with an 8x12 modular flue (.04 m^2) and one with a 16 x 16 modular flue (.086 m^2). The 8 x 12 fireplace has a flue flow of 150 L/s resulting in a 5 Pa (Pascal) house depressurization. The 16 x 16 fireplace results in a flue flow of 450 L/s and a 20 Pa house depressurization. In other words, doubling the flue area quadruples the depressurization in this example



"**The House as a System - Negative Pressure: The Inside Story**" John Gulland, MHA News, Vol 6 No 2, pp 36 - 44.

"...Here's our house: It's 0 degrees Fahrenheit outside and 70 degrees inside. We've got a temperature difference from outside to inside. The result of that temperature difference is that this house is going to develop some stack effect, the way a chimney does. Its going to be a little bit positive high in the house and a little negative pressure low in the house.

That stack effect business is one of the really big reasons why, when we have a woodstove or a fireplace installed in the basement of a house, or we have a chimney that is hung on the outside wall of that house and there is no fire in the stove and its cold outside, we go down in the basement to light the fire and we open the door and what do we get? Cold air, right?

THE HOUSE IS PRODUCING SOME DRAFT, OR STACK EFFECT, AND THAT LITTLE BIT OF NEGATIVE PRESSURE IN THE BASEMENT IS ENOUGHT TO SUCK THE AIR DOWN THROUGH THE CHIMNEY AND OUT THE DOOR OF THE STOVE, RIGHT? BASIC

Why? Because its slightly negative in the basement and the chimney, because its hung up the outside wall, is cooled to outside temperatures, producing zero draft, the house is producing some draft, or stack effect, and that little bit of negative pressure in the basement is enought to suck the air down through the chimney and out the door of the stove, right? Basic.

This is why, of course, we never put chimneys on the outside wall of the house, right? (Laughter from the audience) Never! Because its bad science to put the chimney up the outside wall of the house. We always put the chimney up inside the house envelope. Am I right saying that? I wish!"

R2000 Makeup Air Guidelines, The Canadian Homebuilders' Association, Ottawa, 1993.

"In writing this manual, we know the following about R2000 houses:

1.) They have balanced ventilation systems such as Heat Recovery Ventilators (HRVs).

2.) A competent and HRAI trained mechanical system designer and installer will be used.

3.) Conventional, naturally aspirating combustion appliances are not allowed.

4.) Energy and comfort requirements of R2000 require that make-up air inlets be controlled so that they are only open when needed.

All R2000 houses must meet the following rules:

- local building codes

A COMPETENT AND HRAI TRAINED MECHANICAL SYSTEM DESIGNER AND INSTALLER WILL BE USED

- the R2000 Technical Requirements; which calls up CAN/CSA-F326-M91 *Residential Mechanical Ventilation Systems*

...In R2000 houses with balanced ventilation systems, only the intermittent requirements are of real concern. The intermittent pressure control requirement in F326 can be summarized as follows:

If there is a *vented combustion appliance* (fuel-fired furnaces, hot water heaters, fireplaces, etc.) installed in the house the simultaneous operation (at the same time) of the

ventilation system
the dryer, and
the largest other exhaust device,

must not create a negative pressure in the house of more than -5 Pascals unless the manufacturer of the combustion equipment has certified operation at a higher pressure.

...When this document was written, the only combustion appliances not affected by the -5 Pa limit are those that operate with a completely *sealed combustion system* (combustion air is drawn in from the outside through a sealed air inlet, and exhaust products are vented to the outside through a sealed flue pipe).

So far, no manufacturers of appliances that draw air from inside the house have certified their equipment for operation at negative pressures greater than -5 Pascals. This is true for induced draft furnaces or hot water heaters, and all wood-burning fireplaces and stoves.

... Makeup-up Air Strategies

The size, complexity, and cost of the make-up air system needed in the house depends on the heating and exhaust appliances that are going to be installed. Therefore:

The builder should know what he can do to eliminate or reduce the size of the make-up air system.

The designer and installer of the make-up air system must understand the design requirements of both the heating and the ventilating systems. The use of a single company to address both needs is recommended.

The builder and mechanical designer must start discussing options very early in the design process.

...2.1 Avoid Vented Combustion Appliances

You can eliminate the need for make-up air by using electric or sealed combustion heating and hot water heating appliances or direct vent gas fireplaces, and not using wood fireplaces and stoves.

...Make-up air must be considered when there is a wood-burning fireplace or stove. If the fireplace is necessary for your market, use a direct vent gas fireplace if possible (ed note: *frivolous fossil fuel use - what a concept!*). If you do use wood-burning appliances, make sure you understand the cost implication.

MAKE-UP AIR MUST BE CONSIDERED WHEN THERE IS A WOOD-BURNING FIREPLACE OR STOVE. IF THE FIREPLACE IS NECESSARY FOR YOUR MARKET, USE A DIRECT VENT GAS FIREPLACE IF POSSIBLE.

...2.6 Show Compliance by Field Testing

One can calculate the required size of make-up air systems prior to construction, but the calculations use conservative assumptions. F326 also allows showing that pressure limits are met by field testing in the completed house (*ed note: see "Testing House Pressure and Bringing in Outdoor Air", John Gulland, MHA News, Vol 6 No 2, p. 44*). This nearly always shows that the required size of the inlet is smaller than the calculated size.

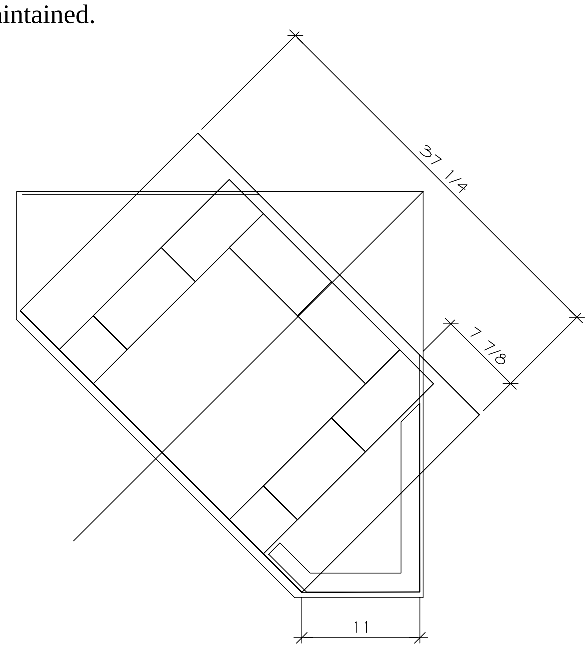
ed. note: This document goes on to give very detailed make-up air methods. It is available from: Canadian Homebuilders' Association, 150 Laurier Ave. W., Suite 200, Ottawa ON K1P 5J4; Tel 613-230-3060 FAX 232-8214.

A sample of available CMHC literature brings up the following:

C. A. McGugan, M.C. Swinton, and S. Moffat, **Fireplace Air Requirements**, CMHC, Ottawa, 1989.

It concludes, among other things:

- Fresh air intakes proved to be of variable utility, supplying close to all required air in some fireplaces and less than 25% in others. Those directly connected to the firebox could match air requirements but could be dangerous in reverse flow incidents, when combustion products flow out through the intended intake.
- Air intakes which are connected directly to fireboxes can experience reverse flow of hot gases through the duct. Therefore these ducts should be isolated from combustible materials. Direct-connected air intakes are not recommended unless the firechamber is relatively tight and isolated from the house when the doors are closed.
- Backflow prevention dampers may provide a solution to the reverse flow problem
- All fireplaces tested would spill, during fire diedown *(tailout)*, if a room depressurization of roughly 10 Pascals was maintained.



J. C. Haysom and David Eyre, **<u>Residential Combustion Venting Failure - A Systems Approach: Project 5 - Make-up Air Supply Remedial Measures</u>**, CMHC, Ottawa, 1987

THE REULTS OF THE TESTS INDICATED THAT THE PROVISION OF ADDITIONAL SUPPLY AIR IS NOT LIKELY TO BE EFFECTIVE AS A REMEDY FOR PRESSURE-INDUCED SPILLAGE OF COMBUSTION PRODUCTS

From the Executive Summary:

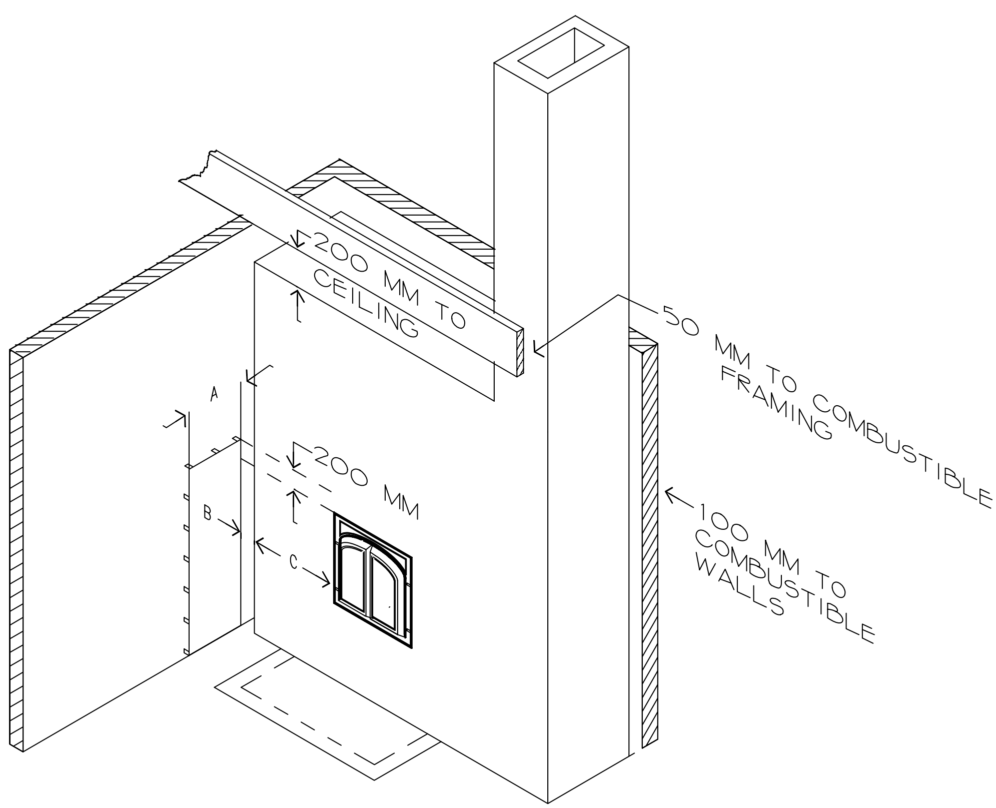
The reults of the tests indicated that the provision of additional supply air is not likely to be effective as a remedy for pressure-induced spillage of combustion products if the supply air is introduced unaided through an envelope opening of any size likely to be considered practical. It is only likely to be effective if a supply air fan is used and if that fan has a capacity at least equal to the total capacity of all exhaust equipment it is attempting to counteract.

CHIMNEYS:

Sebastian Moffat, **<u>Residential Combustion Venting Failure - A Systems Approach: Project 3 - Refinements to the Chimney Safety Tests: Determining House Depressurization Limits,</u>** CMHC, Ottawa, 1987.

(p 14):" Chimney Height:

The effect of chimney height has not been investigated in detail, but it is now thought to be less relevant, especially for exterior chimneys. Calculations by Jim White of CMHC have shown that chimneys have a limited effective height regardless of their un-insulated overall length. This is substantiated by modelling of the exterior masonry chimney: the flue gases at standby were significantly cooler than room temperature in the upper half of the flue, and thus were less buoyant than the house air against which the chimney is competing. Thus, it is not clear that the two storey house chimney would fare better than the bungalow chimney if it were unlined and on the exterior. Only with better flue liner designs (interior, and/or lined) would there be a noticeable (1 Pa) difference with the added height of a 3 storey house, or the reduced height of a bungalow."



G. K.Yuill, **Study of Flue, Furnace and Envelope Parameters Affecting Oil Furnace Start-Up Spillage**, CMHC, Ottawa, 1988.

From the Executive Summary:

•...The transient furnace-flue system performance after firing was simulated using the heating system simulation program FLUESIM...

•An interior flue performs better during start up than the same size exterior flue.

•... Oversized clay-lined masonry flues perform worse than large A-vents. An increase in the size of large clay-lined flues will actually increase spillage times.

•...Flue thermal inertia does not significantly change start-up spillage and therefore should not be considered a design parameter.

•Flue insulation has little effect on start-up spillage after equilibrium at 0 Pa.

•...For low depressurizations, a short flue performs best. However in houses where large backpressures occur, a longer flue is desirable.

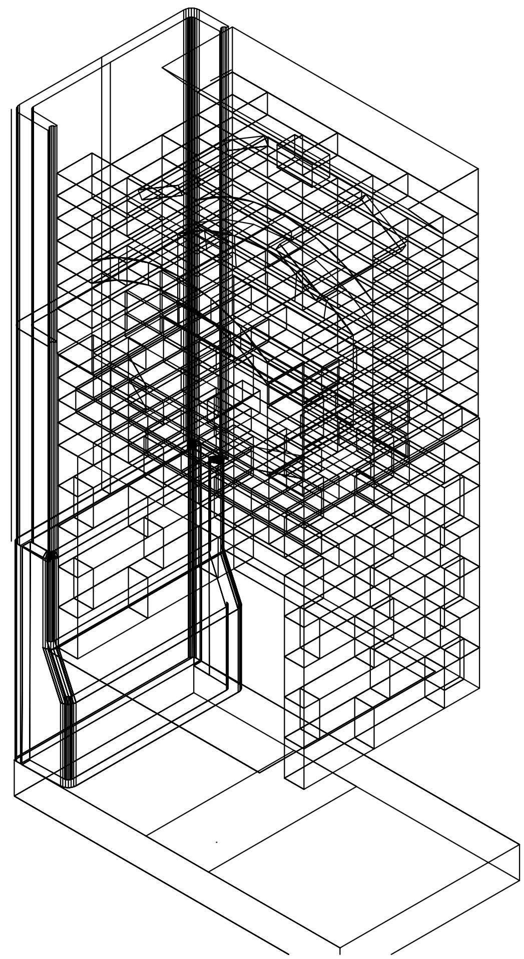
•...Larger flues have slightly more condensation.

OVERSIZED CLAY-LINED MASONRY FLUES PERFORM WORSE THAN LARGE A-VENTS. AN INCREASE IN THE SIZE OF LARGE CLAY-LINED FLUES WILL ACTUALLY INCREASE SPILLAGE TIMES

Oversized masonry chimneys have much more condensation than smaller flues.

•Large thermal inertia of the flue liner increases condensation of the flue gas.

•Flue insulation has little effect on chimney condensation.



SEE YOU IN COURT!

The foregoing lengthy discussions on startup spillage, under certain conditions, may leave the impression that this is an academic subject

An interesting package of documents arrived at MHA News early last winter. It was from a MHA member of several years. After a couple of telephone conversations, we decided that it might prove instructive to other heater masons. Names are withheld by request.

SUFFICE IT TO SAY, THIS GOLDEN TONGUED CONTRACTOR CONVINCED THE OWNER THAT THE ONLY SOLUTION TO HIS LIFE-THREATENING PROBLEM WAS TO DEMO THE CONTRAFLOW AND REPLACE IT WITH THE XYZ

It seems that this stovemason had built a contraflow heater for a client a number of years ago. The heater had an exterior chimney and no bypass. It had airtight doors.

Our anonymous brother explained over the phone that he had no idea the client was having a problem until he was served with a lawyer's letter. It seems that a local mason, a dealer for a now-defunct product line, convinced the owner that the custom contraflow would surely have gassed the owner and his family to death in their sleep if it hadn't been for his fortuitous arrival. He convinced the owner to let him perform an inspection on the unit in question by - wait for it - disassembling it. We don't have space for his inspection report, but it could be quite funny if it weren't so sad.. Suffice it to say, this golden tongued contractor convinced the owner that the only solution to his life-threatening problem was to demo the contraflow and replace it with the XYZ. The owner's lawyer was now attempting to recoup the costs from Mr. MHA Mason. Read on:

Date:

To Whom It May Concern:

I have received from Mr. Heater Mason the following documents:

- Letters from Mr. Client to Heater mason dated October xxx, December xxx, and January xxx.
- Statement of Mr. Dealer dated December xxx.
- Four color photographs of a contraflow masonry heater in various stages of disassembly.
- A description from Mr. Heater Mason of the photographs. The description is as follows:

> "1.) This is the front view of the heater as it is being torn down from the top. The heater was not capped on top with a row of clay brick. I left the firebrick cap exposed on top and insulated the space between the outer brick wall and firebrick, with fiberglass insulation. *(Ed. Note: Don't try this at home, kids.)*
>
> 2.) Closer shot of the same.
>
> 3.) Shot of the front of heater near the top. Firebrick has cracked and smoke has escaped.
>
> 4.) Shot of left side of heater near the top. Smoke damage, but firebrick otherwise remains intact. Notice two layers of firebrick on top. They look like they were in working order."

Mr. Heater Mason has asked me to render an opinion, based on these documents, of the claims made by Mr. Client in his letter of October xxx. Mr. Heater Mason and I have had no discussions on the details of this job other than in very broad terms in one telephone conversation prior to the receipt of the documents.

Based on the photographs, this masonry heater is comprised of clay facebrick, air space and interior firebrick and is connected to an exterior chimney. The air space is capped by firebrick slabs. This is an acceptable method of construction.

Based on the photographs, and on my general knowledge, I would make the following comments regarding the specific claims made in Mr. Client's October letter:

- The photographs do not show a fireplace that "has completely broken down".
- Although I see evidence of a structural crack in the firebrick, I do not see any evidence of firebrick deterioration.

- Carbon dioxide is not generally regarded as a toxic gas. It is possible that Mr. Client may have it confused with carbon monoxide.
- The mortar used to set the firebricks appears to be fireclay based refractory mortar. Most of the readily obtainable mortars of this type are known as air-setting (as opposed to "heat-setting"). Air setting refractory mortars are a mixture of fireclay, water, and sodium silicate, with slight variations between different brands. From the photographs, I can see no evidence of anything out of the ordinary. Nor can I see any evidence of incorrect or improper installation.

Regarding the statement of Mr. Dealer, I would make the following comments and observations:

> FIREBRICK PROBLEMS ARE EXTREMELY RARE IN THE UNITED STATES BECAUSE THIS REGION HAS THE WORLD'S LARGEST DEPOSITS OF HIGH QUALITY CLAY

- I have no prior knowledge of Mr. Dealer and do not presume to make any statements regarding his competence. However, I would make one general observation: It is my understanding that a majority of Brand XYZ dealers are masonry contractors. In other words, the XYZ system allows masonry contractors with no previous knowledge of or experience with masonry heaters to get into the masonry heater business. In fact, the claim that it can easily be installed by almost anyone is used in XYZ sales literature as a selling feature of the XYZ unit.
- A hand-built masonry heater such as is shown in the photographs requires more than a general knowledge of masonry to construct. It is my understanding that Mr. Heater Mason has travelled to Europe for the specific purpose of receiving masonry heater training, and that he had built a considerable number of successful custom masonry heaters prior to the one in question.
- In my opinion, a general knowledge of masonry and masonry fireplace construction, combined with installation experience of the XYZ unit, would not in and of itself qualify someone to render a meaningful opinion on techniques specific to custom masonry heater construction.
- Mortar deterioration, in the context described by Mr. Dealer, assuming the use of commercial air-setting refractory mortar, is highly unlikely for a number of reasons. In particular, any mortar problems would be almost certain to appear in the firebox proper much sooner and to a greater degree, than in the upper chamber of a contraflow heater. This would be even more true of the firebrick itself.
- The only problems that I have ever seen in the United States with standard firebrick were at the "fireback" portion of the main firebox. This is the portion in a contraflow heater that is subjected to the most heat related stress. Various stages of surface spalling of the firebrick would be the most likely indicator of firebrick deterioration. Mr. Dealer states "I inspected the firebox and there were no visible collapsed firebrick." It is highly probable that Mr. Dealer, assuming that he is competent in these matters, would have noticed firebrick spalling at the fireback, particularly since this is the most immediately visible portion of the firebox.
- Mr. Dealer states that approximately 30% of the firebrick were what he terms "honeycomb". I am not familiar with this terminology in the context of clay firebrick. He may be referring to "crazing", which is quite common. In any case, he does not link his presumption of a firebrick flaw with the end result of such a flaw.
- In my opinion, in general terms, if one were to compare "very light in weight" and "the usual heavy quality" firebricks in terms of their suitability for masonry heater construction, the former would actually be more likely to be suitable, for reasons related to thermal cycling. It has been our experience that firebrick problems are extremely rare in the Unites States because this region has the world's largest deposits of high quality clay, particulary in Ohio. As a result, the firebricks typically available through masonry supply yards in this region have a high probability of being suitable for masonry heater construction. I have done extensive research with (deleted) and am of the opinion that very few, if any, (deleted) products are equal in durability to even an "average" northeastern firebrick in masonry heater applications. I would also point out that masonry heater refractories is a specialized field and typically outside of the knowledge base of technical experts in the North American refractory industry.

Based on the documentation already referred to and on my general knowledge, I would make the following further comments:

The cracked firebrick:

The photographs show a vertical crack in the firebrick of the middle chamber, approximately in the middle of the front wall. This type of crack is a result of contraction and expansion and is not uncommon.

Smoking:

(1) It is a generic feature of contraflow heaters that they are subject to start up spillage when connected to an exterior chimney. An indicator of this is the smoke staining on the facebrick work above the loading door, clearly visible in the photographs. An unfavourable start up condition can be corrected by a change in start up technique ("priming" the draft). Start up spillage is easily recognized since the smoke has an acrid smell.

> . AN UNFAVOURABLE START UP CONDITION CAN BE CORRECTED BY A CHANGE IN START UP TECHNIQUE ("PRIMING")

(2) Given the vertical crack in the firebrick of the upper chamber, smoke may have worked its way through the crack to the air space and exited through the fibreglass insulation. This condition would be easy to diagnose and remedy. It would consist of capping by adding one course of firebrick and casting a conncrete slab into the form that is thus created. However, this type of smoke leakage is unlikely, as toward the end of the burn when carbon monoxide levels in the exhaust are elevated, the upper chamber is operating at negative pressure.

(3) Actual smoke leakage into the house would require a crack in the facebrick or mortar. Leaks through the facebrick work are unlikely. If such did occur, the leaks would be indicated by telltale, very localized, soot staining on the exterior face. Based on the photographs, there is no evidence of leaks through the facebrick or fireclay.

Summary:

In summary, I believe

Vertical Crack

It is unlikely that smoke leakage would occur through the vertical crack.

Operational Error

It is likely that the smoking or smoke leakage occurred as a result of improper operation of the masonry heater by Mr. Client as follows:

(1) use of uncured or wet wood

(2) failure to prime draft

(3) failure to clean out ash collected at the bottom of smoke runs

(4) failure to clean out ash collected at the bottom of the chimney

CONCLUSION

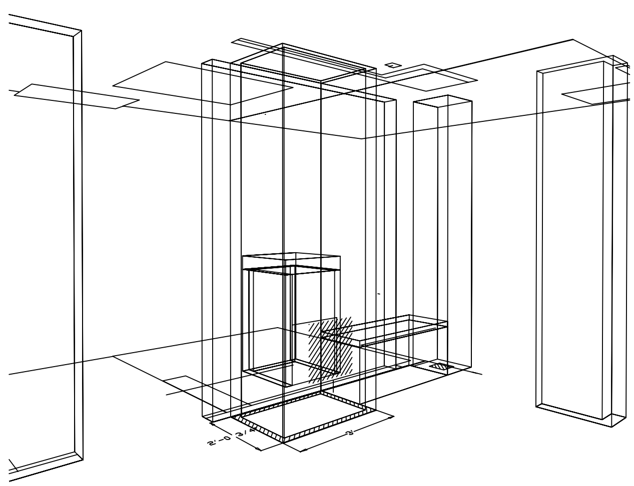
Mr. Client should have contacted Mr. Heater Mason with respect to the smoking or smoke leakage to permit Mr. Heater Mason the opportunity to address the various scenarios outlined above.

None of the above scenarios of smoke leakage would create a life threatening situation.

Respectfully,

Expert Witness

Postscript*: The outcome? The client got reimbursed for 1 day of mason time and the heater mason was out-of-pocket on his lawyer fees.*



Scam Alert

Looking to buy a modular fireplace? Better call Steve Bushway first

In talking with the membership over the years, one of the common threads that has emerged is "the grapevine" - heater masons just love to get together and talk shop. A substantial portion of the collective body of North American stove building knowhow was evolved through this mechanism. Being plugged into this bank of expertise is one of the major benefits of MHA membership.

On the seamier side, the grapevine has often served as an early warning system against scam artists and even the rare bad-news client making the rounds.

Like any business, the masonry heating business is blessed with a tiny minority of bad apples.

Looking to buy a modular fireplace? Better call Steve Bushway first. Here's his letter:

Dear MHA News:

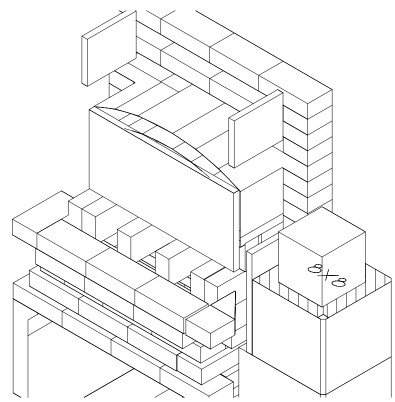
I want to put the membership on notice regarding ordering a certain brand of modular fireplace. As of this writing, Mr. X, the manufacturer of these modular fireboxes is not returning to me $523.40 from an order I placed and cancelled.

Mr. X had me send a registered check to him so he could send me "direct" some of his units that I needed for a job that was scheduled to happen 2-1/2 weeks later. This way I could avoid having to pick them up from the distributor who didn't have any in stock and is located two hours drive away.

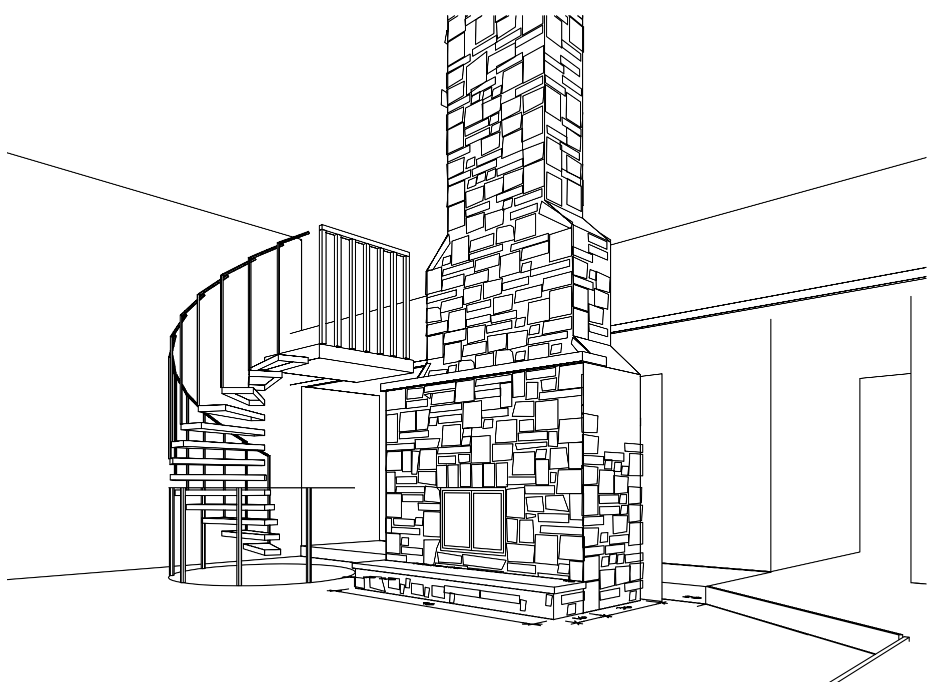
After receiving my check, Mr. X said my order was in stock and was being readied for shipping. After waiting two weeks to hear from the shipper, I started leaving messages on Mr. X's answering machine requesting information on my order. He finally called back and told my wife one of the items I ordered was not available. When I was finally able to speak to him he informed me my order wasn't shipping as he was still waiting for my check to clear!

At this point, I cancelled my order and requested my money be returned immediately. After another 2-1/2 weeks, I got a partial refund and a "statement" charging me restocking fees and "no return" for an item on the price sheet that is "custom". I am pursuing this as mail order fraud with the Department of Consumer Affairs and want to publicize these fraudulent business practices...Call me for details.

(Steve's number is (413) 458-9660.)



Custom Stone Heater with White Oven



HOW TO DIAL UP E-MAIL

With a PC, it's a cheap and easy way to connect with the world

(*Reprinted from Financial Times of Canada, Sept. 18, 1993)*

Like many people, Edwinna von Baeyer works from home. And as for many house-bound workers, the phone and fax were her lifelines -- until whe discovered electronic mail. "E-mail is just wonderful," says the Ottawa freelance writer/editor. "It opens up the world."

Rather than submitting work proposals via long-distance phone or fax, von Baeyer "E-mails"her outlines to faraway editors, via her Macintosh, a modem and subscription to a local E-mail service, There's never a long-distance surcharge or busy signal.

Instead of phoning her friends in Missouri and Finland, von Baeyer also send her tidings via computer. Soon she'll use E-mail to stay in touch with her daughter, a University of New Brunswick student.

Von Baeyer is among a fast-growing cimmunity of personal computer owners using their home PC's to beam short documents cheaply and conveniently around the globe. Be the end of last year, there were 110,000 public E-mail users in Canada, up from about 30,000 five years ago. By 1997, that figure should nearly double to more than 200,000.

As its name suggests, E-mail is analogous to conventional mail, using a mailbox and address. In this case, the mailbox is a dedicated space in your E-mail company's computer, while the address is an alphanumeric code that routes messages to your mailbox. The mailbox can receive and store correspondence while your computer attends to more important business, or is turned off. Then, when you're ready to read your mail, you log on to the system and a message will automatically tell you there's E-mail waiting.

Unlike the postal service, which uses surface and air routes, E-mail travels over the many worldwide data networks of phone companies, private corporations, govenments and universities.

Among the largest commercial providers of E-mail are the phone companies themselves, which carry mail nationally over their own dedicated data lines, and internationally via contracts with foreign telephone companies. The service owned by the regional telephone companies, WorldLinx Telecommunications Inc., offers a system called The Net, available by dialling locally in most Canadian cities. Unitel Communications Inc. of Toronto offers a similar worldwide service called AT&T Mail.

Two major U.S. electronic-information companies, GEnie and Compuserve, also offer worldwide E-mail services in Canada. Less well-known are hundreds of smaller, locally based firms; among the biggest is CRS Online, which originates in southern Ontario.

Prices vary considerably, so it's worth shopping around. To find a local E-mail link in your area, consult the Yellow Pages under Information Services. And The Computer Paper, a Vancouver-based magazine, publishes a list of services.

Most services, including The Net and AT&T Mail, charge a small monthly subscription cost of $5 to $15, plus a per-transmission charge based on the size of the message (15 cents to $2.10 a letter-size page). GEnie charges a flat $10.95 a month for up to four hours of on-line time, plus $4 for each additional hour. CRS Online charges a flat $130 annual subscription, which gets you two hours of daily on-line time.

EQUIPMENT REQUIREMENTS TO TAP INTO E-MAIL ARE MINIMAL

Equipment requirements to tap into E-mail are minimal, but you can save considerable cash by making some wise choices up front. Faster modems (2400 baud and up) will save on-line time. Many E-mail providers offer their own proprietary telecommunications software packages, which simplify the transmission procedure. Prices range from free to $250.

Communicating via E-mail also has less obvious advantages. For example, many users say they're more likely to trade thoughts when they know they won't be intruding on important business.

E-mail also allows users to collect their thoughts more systematically than they would in a phone conversation, but less effortlessly than for a formal letter. At the same time, using E-mail tends to dissuade the daily small talk that can slow down business exchanges and increase phone bills.

One E-mail disadvantage is the lack of privacy. It's quite easy for system supervisors to eavesdrop on private mail as it passes through their network computers, so don't send anything you'd be embarassed to have a stranger read.

And for all its advantages, don't expect E-mail to replace the phone. Fortunately or not, modern technology has yet to find a substitute for the persuasive power of the human voice.

Air Requirements and Related Parameters for Masonry Heating Systems

Prepared for:

The Reserch Division
Housing Technology Incentives Program
Canada Mortgage and Housing Corporation

CMHC Project Manager: Don Fugler

Prepared by:

Norbert Senf
Masonry Stove Builders

March 3, 1994

EXECUTIVE SUMMARY

Masonry heaters are woodburning appliances that have the ability to store heat in a thermal mass. Typically, a 10 to 20 kg wood charge is burned rapidly with a liberal air supply, and a 1 to 2 hours burn will yield a continuous heat output for 12 to 24 hours. Because energy storage makes a low heat output possible without having to resort to smoldering burns (ie., low burn rates), it allows cordwood fuel to be burned with very low emissions of atmospheric pollutants.[i] Although based on designs that are hundreds of years old, the operating characteristics of masonry heaters make them particularly suitable for modern, energy-efficient housing. However, it is not clear how much air they will draw from the house during operation.

This research was designed to answer that question. Various aerodynamic parameters were measured on five different masonry heaters, with the aid of a specialized piece of testing apparatus, the CMHC duct test rig. Air consumption data was obtained under a variety of operating conditions. Air leakage was investigated in two heater systems, as were the tailout (diedown) characteristics. Finally, the air leakage on four types of masonry heater firebox doors was tested.

Masonry heaters with overfire combustion air systems appear capable of operating with maximum air consumption rates of 30 L/s or under. The underfire air units tested required considerably more air. In a typical R2000 house, drawing 30 L/s of inside air would result in only about 3 Pascals (Pa) of depressurization, well within any house depressurization limits.

If the heaters were fitted with a separate outside air supply, the only air requirement from the house would be the air leakage through the doors. Testing on a number of doors showed that the leakiest door would draw only 6 L/s at 25 Pa, an amount that would not cause any noticeable degree of house depressurization.

One problem with some wood heating devices is that the chimney flow may reverse when the fire dies down, causing smoke and/or carbon monoxide spillage into the room. Testing showed that this is not an issue with masonry heaters, as the basic design stores large amounts of heat that maintain chimney draft even after the fire subsides.

The data supports the view that the majority of masonry heater types can be expected to function properly in airtight houses, with or without outside combustion air supplies.

DISCLAIMER

THIS PROJECT WAS FUNDED BY THE CANADA MORTGAGE AND HOUSING CORPORATION. THE VIEWS EXPRESSED ARE THE PERSONAL VIEWS OF THE AUTHOR. THE CORPORATION DOES NOT ACCEPT RESPONSIBILITY FOR THEM.

INTRODUCTION

Masonry heaters are heat-storing appliances. They have been in use for many years in the colder regions of Europe. Prior to 1981 they were almost completely unknown on this continent, but have been making steady inroads since. Recent North American testing indicates that as a class they are capable of operating at the very low average particulate emissions (PM) levels necessary before biomass fuels can become a viable household-level energy option. This could be of significance to recent trends in “green” architecture, since biomass is potentially a zero net carbon impact (renewable) fuel. Masonry heaters are particularly well matched to operation at sustained low output levels (.5 - 3.0 kW) typical of the average heating load in new energy efficient housing. The present report investigates several aerodynamic characteristics of these appliances that may affect their performance in low energy housing that is airtight. The author conducted tests with the CMHC Duct Test Rig (DTR), a specialized tool that is capable of measuring a wide range of airflows and pressure versus flow (impedance) characteristics. Specifically, the air consumption of masonry heaters was measured in two combustion air configurations (overfire and underfire). Secondly, tailout was investigated. This is the resistance of a solid fuel appliance to pressure induced combustion gas spillage at the end of the burn cycle, when carbon monoxide production typically is high. The third item investigated was the airtightness of several standard masonry heater firebox doors. It also became apparent during the testing that air leakage in the masonry heating system as a whole needed to be addressed. Finally, some leakage and calibration considerations of the DTR itself were investigated.

Masonry Heaters.
Masonry heaters are characterized by a large masonry thermal mass that is used for heat storage. A charge of cordwood fuel of up to 25kg. is loaded into the firebox, ignited and then rapidly burned. Much of the resulting heat energy is transferred into the masonry mass through direct radiation in the firebox and through flue gas heat exchange channels, and is then slowly released into the heated space over a number of hours after the fire is out. A typical one to two hour burn will result in a 12 to 24 hour heat release, depending on the heater type.

Heaters Studied.
All of the heaters investigated in this report are of the contraflow type. Originating in Finland, these are regarded as being the most fireplace-like of the masonry heaters, and are the most common type built in North America. They are characterized by a raised firebox and a set of downdrafting heat-exchange channels that terminate in a chimney exit at floor level. A secondary characteristic of all the heaters tested is that there is no combustion air control except for on/off in three of the heaters. All of the heaters incorporate a sliding damper in the chimney which provides the only control. Its main purpose is to interrupt chimney flow once the fire is out, since the burn itself is essentially unregulated except for the throttling at the combustion air inlet orifice.

Five heaters were investigated. One (RUP) was handbuilt by the author in 1981, and is one of the earliest modern contraflow heater built in Canada. The second heater (TEM) is a current production model manufactured in Canada by Tempcast Industries, and consists of precast refractory modules that are site-assembled into a heater "core". The heater core then receives a site-installed masonry facing, typically 100 to 150 mm in thickness. It was tested at the Tempcast factory as a core with no facing. The other three heaters are examples of a second Canadian system, Heat-Kit. It is a hybrid system in that the core uses precast factory components that are combined at the site with standard refractory modular units (firebricks). This system was developed by the author's company in 1985. One unit (MSB) was a prototype core that was tested with no facing. The second one (SEN) was a core with a prototype facing, and the third (AND) was a core with a typical clay brick facing. Typical operating parameters for the heaters studied are:

Firebox size: .09 to .12 m3
Fuel load: 15 to 25 kg (wet basis @ 20% moisture)
Firing cycle 24 hours (typical) or 12 hours (high output)
Average output: 2-3 kW (typical) or 4-6 kW (high output)
Storage Capacity:............50 kW-h (typical)

AIRTIGHT HOUSING AND MASONRY HEATING ISSUES

Outside Combustion Air.
With the advent of more efficient housing standards, the use of direct-connect outside combustion air supplies for vented appliances has become an issue. CMHC funded a study of fireplace air requirements in 1989[ii]which concluded the following:
Fresh air intakes proved to be of variable utility, supplying close to all required air in some fireplaces and less than 25% in others. Those directly connected to the firebox could match air requirements but could be dangerous in reverse flow incidents, when combustion products flow out through the intended intake.
Air intakes which are connected directly to fireboxes can experience reverse flow of hot gases through the duct. Therefore these ducts should be isolated from combustible materials. Direct-connected air intakes are not recommended unless the firechamber is relatively tight and isolated from the house when the doors are closed.
Backflow prevention dampers may provide a solution to the reverse flow problem
All fireplaces tested would spill, during fire diedown *(tailout),* if a room depressurization of roughly 10 Pascals was maintained.

Current Building Codes. A few masonry heater models are ULC listed and are thus installed in accordance with the terms of their listing. Most masonry heaters however, even factory kits, are typically site-assembled and are usually accepted under the masonry fireplace and chimney provisions of the applicable building code. The National Building Code of Canada has for several years had a requirement for a 100 mm outside air duct vented directly into the firebox of masonry fireplaces. The above-mentioned study, and others, have pointed to possible deficiencies in this arrangement[iii]. Recently, there have been several well-documented cases of complete draft reversals in factory-built fireplaces where the air supply has become a chimney and the chimney has become the combustion air supply. This is quite plausible, and even expected, theoretically.[iv] When there is wind loading on a house, the windward side sees a positive pressure while the three leeward sides see varying degrees of negative pressure. In other words, the supply hood for the fireplace combustion air has a less than even chance of seeing zero or positive pressure during wind loading. Up to 50 Pa negative wind pressure is not unheard of, enough pressure to overcome the chimney draft. No building code presently addresses this issue.

Regulatory Rationale. At least one housing standard, the voluntary R2000 performance standard, has addressed outside combustion air. It was argued that EPA (United States Environmental Protection Agency) -certified appliances due to the nature of their construction, were unlikely to consume air at a high enough rate to cause an airtight house to exceed the commonly accepted HDL (House Depressurization Limit) of -5 Pa. It was reasoned that, by requiring all solid fuel devices to be EPA certified, outside combustion air could be eliminated. This approach creates certain difficulties for masonry heaters. First, EPA certification is clearly only a surrogate standard, since it regulates PM (particulate emissions) and efficiency, but not air consumption. Presumably air consumption rates can be inferred. Unfortunately, masonry heater are classed as “non-affected facilities” by EPA and therefore uncertifiable under EPA rules. Recent experience in the solid fuel industry indicates that once standards in new areas of regulation are adopted, they have a tendency to propagate and become a defacto status quo. The EPA rule is an example of this. There is therefore some urgency attached in the masonry heating sector, still in its infancy in Canada, to establishing a performance database that can serve as a basis for establishing sound future standards.

House Depressurization.

Negative house pressure can contribute to spillage at startup and at diedown. It can be induced by exhaust appliances, by wind loading and by stack effect. An HDL of -5 Pa is commonly used. Negative house pressure relates to masonry heaters in two ways. The primary concern has been the issue of air consumption by the heater, ie., the heater causing negative pressure in the house. A secondary issue is the effect of house negative pressure on the heater, ie., will spillage occur and under what conditions?

Spillage: Outside Air and Airtight Doors.

A popular concept with airtight housing has been the idea of aerodynamically decoupling the appliance from the house. Airtight doors, so the theory goes, will prevent a fireplace from spilling into a depressurized house at startup or diedown. The 1989 Sheltair tests[v] found little relation between door tightness and spillage susceptibility. Similarly, theoretical work with WOODSIM found flaws in this concept[vi]. Negative house pressure is, by definition, negative relative to ambient outside pressure. Since the effect of an outside air supply is to bring the firebox to outside pressure, it cannot be demonstrated to prevent spillage. Similarly, a door that leaks 5 L/s at 10 Pa is considered to be quite tight for a fireplace door. Five litres per second of acrid woodsmoke is not a negligible amount. Notwithstanding these considerations, the airtight door concept remains a popular one. “How tight is tight?” becomes the next question. In order to investigate this, a special door test enclosure for the DTR was constructed, and a number of pressure vs. flow tests were carried out on a selection of doors in general use in masonry heaters.

Tailout.

Tailout is the term used to describe phenomena at the die-down stage of a solid fuel burn. As the wood charge is consumed, chemical energy conversion slows in the charcoal phase. Less heat is available to energize the chimney, and other factors such as dilution air can contribute to chimney cooling. The thermal flywheel effect of stored heat in a high mass (masonry) chimney can help maintain draft. So can elements such as firebrick linings in fireplaces and stoves. Low mass chimneys, and chimneys of any type that are outside the building envelope, cool faster. Certain combinations of circumstances can become dangerous. The greatest potential danger is a draft reversal, i.e., combustion gas spillage, during the charcoal phase of the burn: carbon monoxide levels are high at this stage, and there is no smoke to alert the occupants, as there is during startup. CMHC has previously conducted a major series of studies under the title “Residential Combustion Venting Failure - A Systems Approach”[vii] and identified interactions among different parameters in the house/appliance system.

Underfire air.

One of the current issues in masonry heater design is the question of overfire versus underfire combustion air. This refers to whether or not air is introduced to the fuel charge from below, through a grate in the firebox floor. Emissions testing conducted by the author and others[viii]on masonry heaters recently indicates a 100-400% increase in particulate matter (PM) emissions with some common underfire air systems. Also, excess air levels are significantly higher. Excess air refers to the amount of combustion air over and above the theoretical amount (stochiometric) required to complete the oxidation reactions when wood burns. Air consumption by the heater is a function of two parameters, burn rate and excess air. Since underfire air increases the burn rate as well, it was expected to be one of the main variables influencing masonry heater air consumption rates.

TEST PROCEDURE

Data Collection.
Several spreadsheet forms were designed in Excel for Windows. The main form is for the air consumption tests. Background information and test data is entered. Air flow data from the DTR is read as a flow pressure across one of six orifices which are selected by detents on the DTR. The detent letter and flow pressure are entered in the appropriate columns, and the spreadsheet then uses a lookup table to calculate the flow in L/s. As the data is entered, the spreadsheet automatically constructs a graph of flow vs. time. The completed data form and the graph are then printed out as two separate pages. Several test runs use an expanded version of this template to record and display up to three channels of temperature data as well,

A modified version of the template is used to record pressure versus flow and damper opening versus flow data and display the data on a log-log graph.

DTR Calibration.
It was felt prudent to establish some kind of calibration for the DTR that could serve as a reference at a later date if required. Accordingly, flow vs. pressure curves were taken with a set of square orifices cut from a sheet of heavy mylar. If the same orifices are used for a future retest, they will relate the state of calibration of the DTR for this test series relative to any future recalibration of the DTR.

Air Consumption.
On all of the heaters, the air flow at the combustion air intake was measured. Only one heater (RUP) had an air inlet in the firebox door itself. Since it was not a glass door, it was fairly easy to construct a hood to cover the entire door without overheating the hood. The other heaters all had ceramic glass doors, and also had air inlets that were separate from the doors. An average burn has an energy conversion rate in the 20 - 40 kW range, and therefore heat release through the ceramic glass is considerable. Since separate door leakage tests were conducted, it wasn’t deemed necessary to construct special heatproof hoods for the glass doors. Instead, air flow was measured at the combustion air inlet. This is equivalent to measuring air flow at a direct-connect outside air inlet, if installed.

Underfire Air. In order to investigate the effects of underfire air on air consumption rate of masonry heaters, an underfire air heater (AND) was retrofitted with overfire air and then retested. In addition, two heaters (SEN, MSB) that had already been retrofitted from underfire to overfire, were retested with the retrofits removed

Tailout.

Several tests were conducted to examine tailout on masonry heaters. Three heaters (SEN, AND, RUP) were fired on normal cycles. Standby or residual airflow was measured prior to each test run. On several runs stack temperatures were measured before, during and after the burn for various intervals, including long term decay.

System Leakage.

An unanticipated consideration was that of overall system leakage. After discussion of preliminary test results with Skip Hayden (CCRL), the low measured air consumption rates were called into question on theoretical grounds. Although no flue gas analyses were undertaken in connection with the present study, existing data from CCRL and a number of other sources[ixxxixii]on the Tempcast and Heat-Kit systems provided estimates of expected excess air levels. On one system in particular (SEN) air consumption was significantly lower than expected. A metal hood was constructed to measure both door leakage and door mounting leakage and to allow a tight connection to be established with the DTR in order to conduct a flow vs. pressure test of the whole system. System leakage was much higher than expected. Since the facing on this heater was not typical, a more typical heater (AND) with a standard brick facing was retested for flow vs. pressure.

Door Leakage.

A door test enclosure was constructed to allow the mounting of various doors for flow vs. pressure tests. First, a flow vs. pressure test for the door enclosure was conducted. Then, three commercial masonry heater doors from Finland and one from Canada were tested. A typical clean out door was also tested.

Damper Curves.

All of the heating systems incorporated sliding plate (guillotine) chimney dampers. Standby damper leakage, cold and hot, was measured. In addition, curves of flow vs. damper opening were generated for 4 dampers and for a WOODSIM damper simulation.

DESCRIPTION OF THE TESTS

General**.** The data file name precedes the description of the tests.

Fuel. Fuel for the first six tests (01TEM, 02SEN, 03SEN, 04SEN, 05MSB, 06MSB) came from the same stack of firewood, which was split maple and beech that had been in a woodshed for about 16 months. A sample piece was dried in an oven and found to have a wet basis moisture content of 17%. The remaining tests used the owner's firewood.

01TEM.
This was a current production Tempcast contraflow heater core. It was tested at the factory in Port Colborne, Ont. The DTR malfunctioned during the first test, resulting in a lengthy delay for repairs and a subsequent retest several months later.

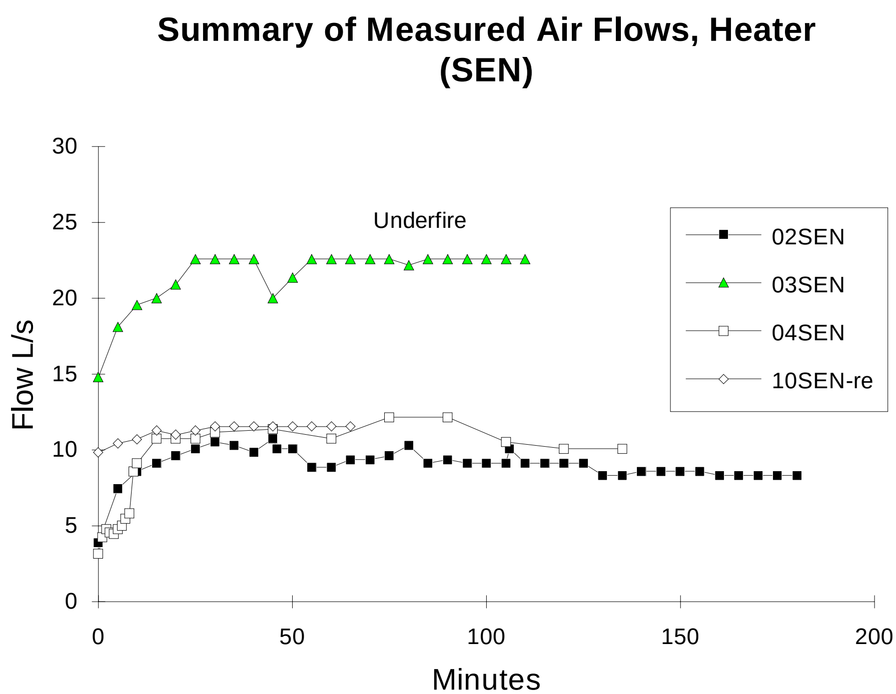
The core was tested without a facing. Joints in the refractory modules had been sealed previously with silicone. The combustion air connection was in the bottom face of the door frame. The door frame consisted of 50 mm x 100 mm hollow steel tubing which is used to preheat the combustion air and convey it to the top of the frame. From there it exits downwards through four 12 mm x 180 mm slots which also function as an airwash for the door. The door was a new model single door with glass. It was gasketed and appeared to be airtight. The glass frame was cast iron. A masonry duct was constructed to make a connection between the somewhat inaccessible air inlet and the DTR. Firebox dimensions were 460 mm x 460 mm x 460 mm. Flue gases exited the heater to the rear at the base, went into a short masonry chimney stub and then transitioned into 200 mm dia. A-vent (stainless steel chimney with 25 mm of insulation). A sliding damper was incorporated into the stub chimney at floor level. The total stack height was the highest of all the heaters tested at 12.2 m. The system was equipped with thermocouples in the stack at floor level and at a height of 5 m, and at the firebox throat. Temperature data was therefore recorded as part of the test.

The heater had been fired with a small (approx. 6 kg) charge of wood about 4 hours previously. This is evidenced in the beginning stack temperatures of 86 C (floor level) and 64 C (5 m height). A Tempcast employee stacked the fuel in the firebox and ignited the charge from the top. The top ignition accounts for a slower start as evidenced in temperature peaks at 70 minutes relative to peaks with a similar fuel charge at 40 minutes in test 05MSB (overfire) and 35 minutes in test 06MSB (underfire).

02SEN.
This is a contraflow heater with a Heat-Kit core. Outside temperature was -17 C, so one would expect maximum chimney buoyancy and flows. Combustion air on this heater enters from the firebox floor immediately adjacent to the doors, ie., at the bottom and to the front of the wood charge. Combustion air consumption peaked at 11.2 L/s. A conservative instantaneous burn rate at the peak would be the 7.4 kg/hr (dry basis), based on burning 17.7 kg of wood with a 17% moisture content evenly over 2 hours. The stochiometric air requirement for this is approximately 10.5 L/s. Since excess air of at least 200% would be expected, the measured combustion air flow is clearly low.

The doors on this heater had undergone several years of "torture testing" and were considered to be fairly leaky. Subsequently, a hood was constructed to cover the door and the heater was retested (10SEN-re) and a leakage investigation carried out (LK-SEN).

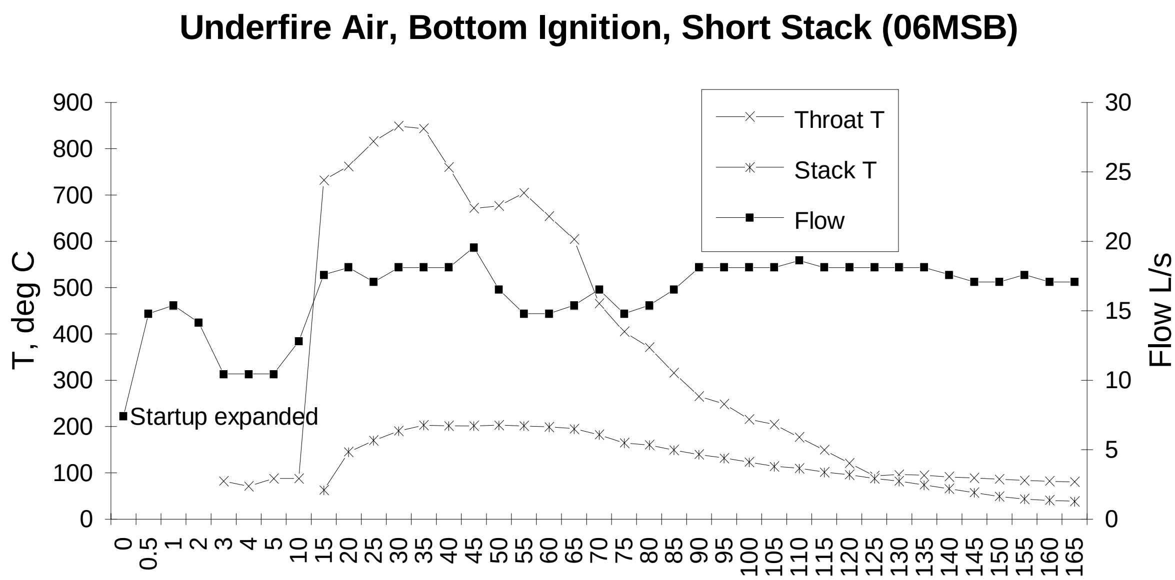
03SEN.
This was a repeat of the above test with the heater "un-retrofitted" to underfire air. This simply consisted of removing the cover on the grate in the firebox floor. Interestingly, with a -25 C outside temperature and with the grate uncovered, we see a standby flow before the burn of 14.8 L/s, or 3.6 L/s higher than the flow during the burn in 02SEN. The airflow through the intake during the burn is doubled from the overfire configuration, at 22.6 L/s. At 45 minutes we see a temporary 2.6 L/s drop as the fuel charge collapses and covers part of the grate.

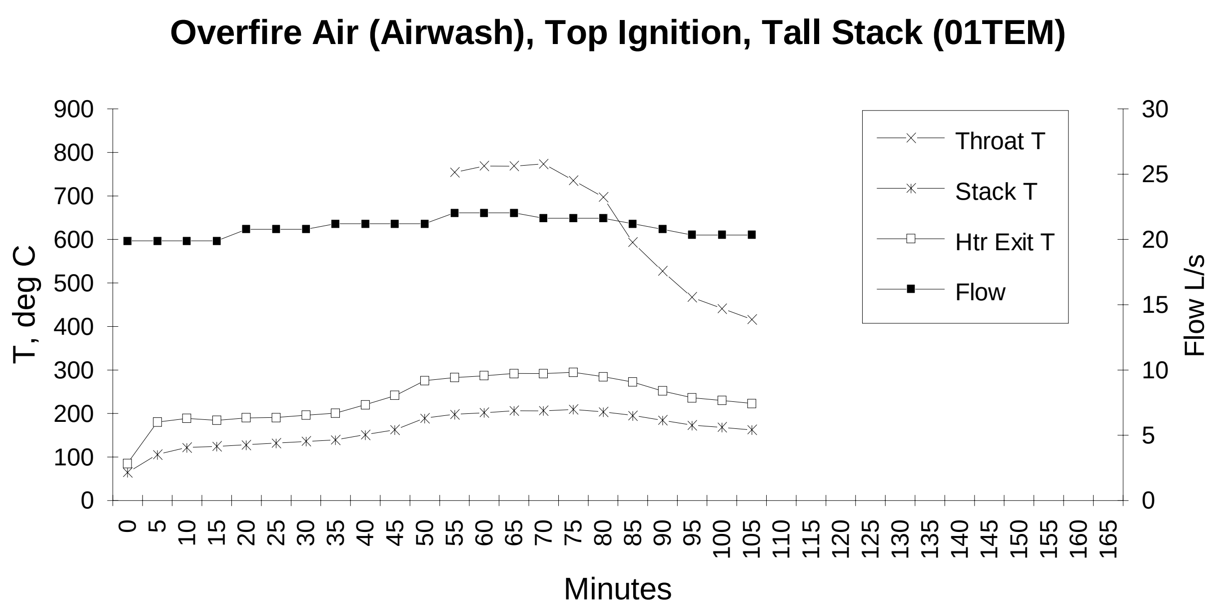


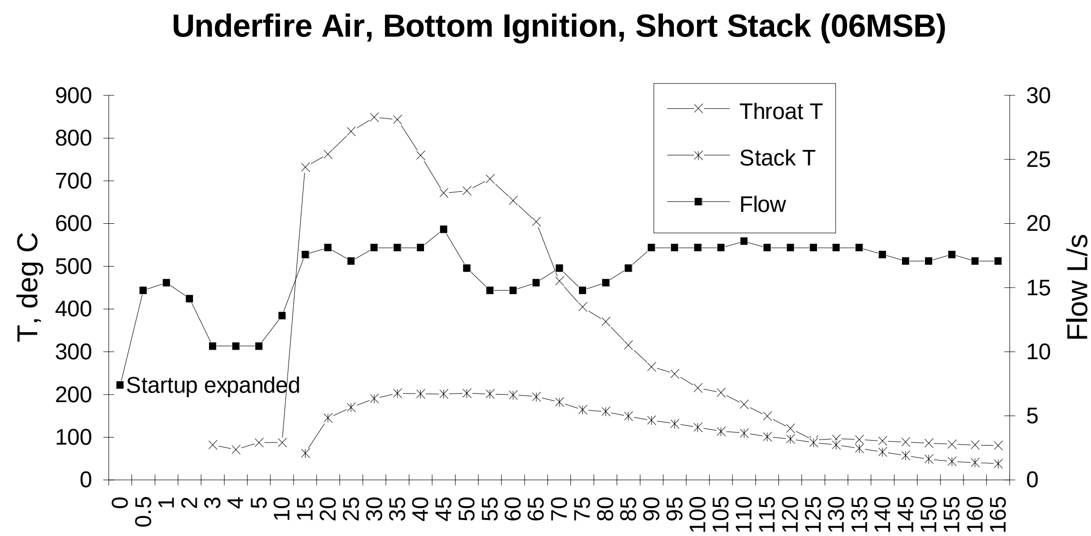
Even though leakage considerations are unresolved at this stage in the testing, we can still gain information from relative flow values. Tailout data is gathered in this test. The damper is closed at 135 minutes, with the flow at 22.6 L/s. The damper is reopened and the flow measured at 160, 220, 340, 400, 460, and 2140 minutes. Thirty five hours after the start of the burn, the chimney flow is 14.8 L/s, the same as the standby flow at 0 minutes. At 340 minutes on the full page graph (in the appendix) we see the change in flow as the damper opening is varied.

04SEN.
This is a repeat of 02SEN, with similar results.

05MSB.
This heater is a Heat-Kit core with no facing. It also has leaky doors, similar to (SEN), so door leakage information from (LK-SEN) would be applicable. It is used to heat a workshop and has the shortest stack of all the heaters studied. The chimney walls







are 3” firebrick with no lining. For this test the heater is fired from a cold start (no previous fire). Airflows are low, and from (LK-SEN), we expect air leakage through the core. Stack temp is measured below the damper at about 2.5 m and peaks at 156 C. Throat temperatures are measured and shown on the graph.

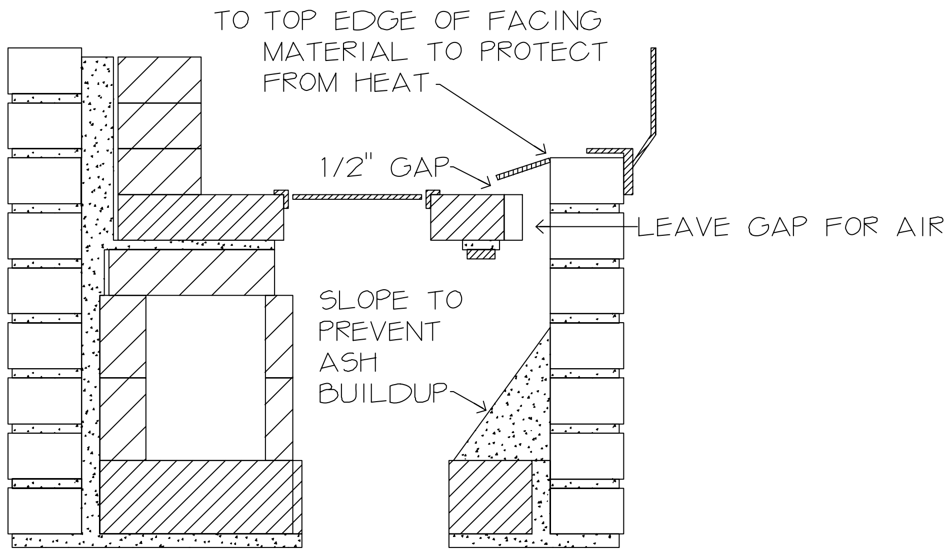
At 190 minutes on the graph we see 75 minutes of stack temperature and flow decay compressed into one data point, followed by a damper curve.

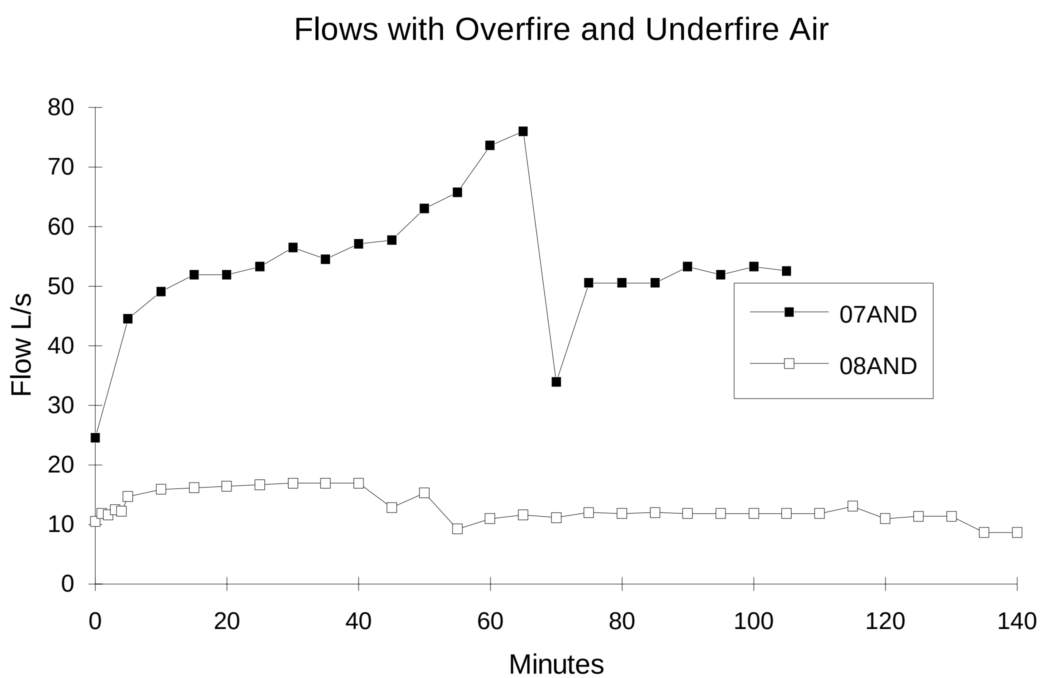
06MSB.
Again, an underfire air “un-retrofit”. Underfire/overfire flow ratio (06MSB)/(05MSB) at 1.8 is similar to heater (SEN) at 2.1. Even with higher excess air[xiii], the throat temperature peaks 33 degrees higher because of the faster burn rate. The shape of the stack temperature “areas” on the graphs are characteristic[xiv] for the two different burn regimes.

07AND.
This is a Heat-Kit core with a standard clay brick facing. This heater was retested for leakage in (LK-AND). Of all the heaters tested, this installation is most representative of those found in the field. It has underfire air, as did almost all contraflow heaters built in North America between 1985 and 1992. The restrictor on a second air slot in the floor had become displaced, effectively increasing the grate area.

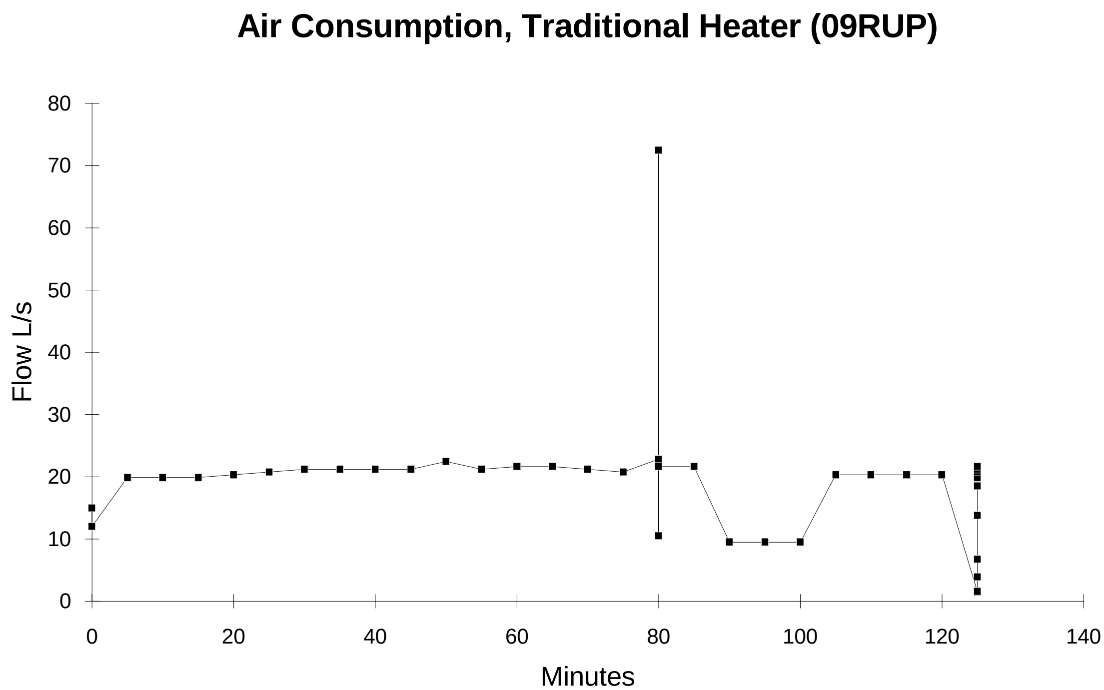
This fire had the highest burn rate of any of the tests. This was evidenced visually by the intensity of the fire, although “airflow in the firebox” might be a better term. The flue gas in this heater travels through a 2 m long heated bench before it enters the chimney. A heavy fly ash buildup was evident in the bench, an indication of very high flow rates.

08AND.
The combustion air system received the standard Heat-Kit retrofit shown below.
The reduction in air consumption from 07AND is dramatic at approximately 75%.





09RUP.
This is perhaps the most interesting heater in the test series. It was built in 1981 and is the earliest Canadian example of a modern contraflow heater. It has a set of Finnish double cast iron doors that are ungasketed, identical to the ones pressure tested in (34DOOR). The air inlet is in the doors, and there are fold-out cast iron screens behind the doors. The doors are in mint condition. The identical doors in (34DOOR) were used for about a year in an underfire air heater, and the cast iron screens are severely warped due to the lack of cooling by the door air.



This heater has been in continuous use for 13 years. Although it has a bypass damper, the bypass has never been needed for startup. Interestingly, neither the chimney or the heater has ever been cleaned. The chimney was inspected last summer and found to still have the red flue liner visible beneath a very light coating of soot. In a separate test, 27 kg. of hardwood were burned. The stack temperature was measured at the chimney exit and found to peak at 110 C.

This is the only heater tested that didn't have an 18" (457 mm) wide firebox. It has a 22.5" (571 mm) wide firebox. The sliding chimney damper is located on the second floor. A plywood hood was constructed to cover the doors and connect to the DTR, since the air supply is in the doors. The only unaccounted airflows would be leaks through the masonry facing itself, so the airflows from this test and from 08 AND would be the most reliable direct indicators of masonry heater air consumption for overfire air.

At 80 minutes we see the air consumption with doors open (screen closed) and doors and air closed (door leaks only). See full description in data file (Appendix B).

Leakage and Tailout Test: 10SEN-re.
This is a more detailed investigation of sources of leakage in heater (SEN). The standby flow in the chimney is measured by opening the 190x150 (.0285 m2) chimney cleanout immediately adjacent to the heater with the heater blocked off from the chimney. The chimney flue open area is 165x266 (.0439 m2 , 8”x12” modular clay liner). We see a 10.4 L/s flow through the cleanout and a 4.0 L/s flow at the combustion air inlet (cleanout closed).

Next, we install a metal hood that covers both the doors and the combustion air inlet. Standby flow through the open doors is 14.8 L/s, through the open air intake and door leaks (door closed) is 7.6 L/s and through door leaks only is 4.0 L/s.

We then conduct a burn with this arrangement. With the hood, airflows are 1-2 L/s higher than in 02SEN and 04SEN, although outdoor temperature is 10 degrees (C) warmer. The test is terminated at 65 minutes because of overheating problems with the hood.

At 180 minutes with the system hot, we conduct a series of “draft” measurements, using the DTR on detent G (closed) as our draft gauge. These readings are lower than actual draft due to leakage at the DTR foam collar:

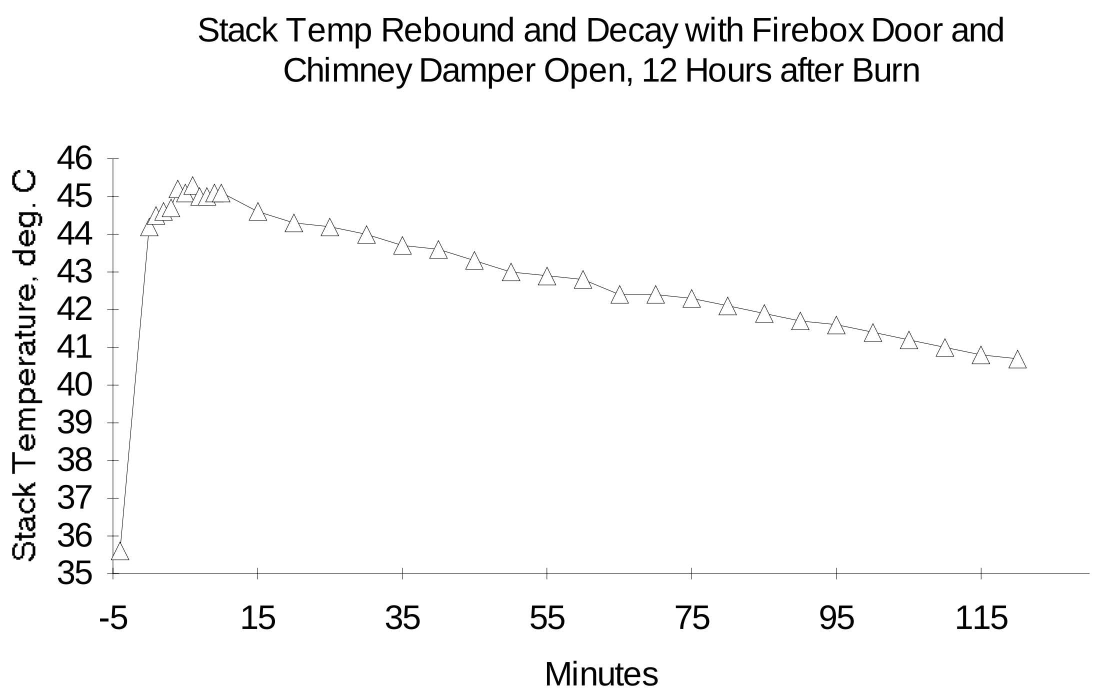
		Chimney Clean Out			**Firebox Doors**		**Combustion Air**	
Flow L/s	**Draft** Pa	Open (.0285 m2)	Reduced (.0077 m2)	Closed	Open	Closed	Open	Closed
	-6.9			X		X	X	
	-4.1		X			X	X	
	-1.1	X				X	X	
	-10.2			X	X		X	
9.5				X		X	X	
8.2				X		X		X
20.6				X	X		X	
17.1			X		X		X	
9.2		X			X		X	

With the system hot, there is an 8.2 L/s flow through door leaks. This is a worst case scenario, since the “torture tested” doors are much leakier than any in actual use. A new set of these doors is tested in (32DOOR), with a leakage of 2 L/s at 25 Pa. The leakage testing of this heater is continued in (LK-SEN) with a flow vs. pressure test.

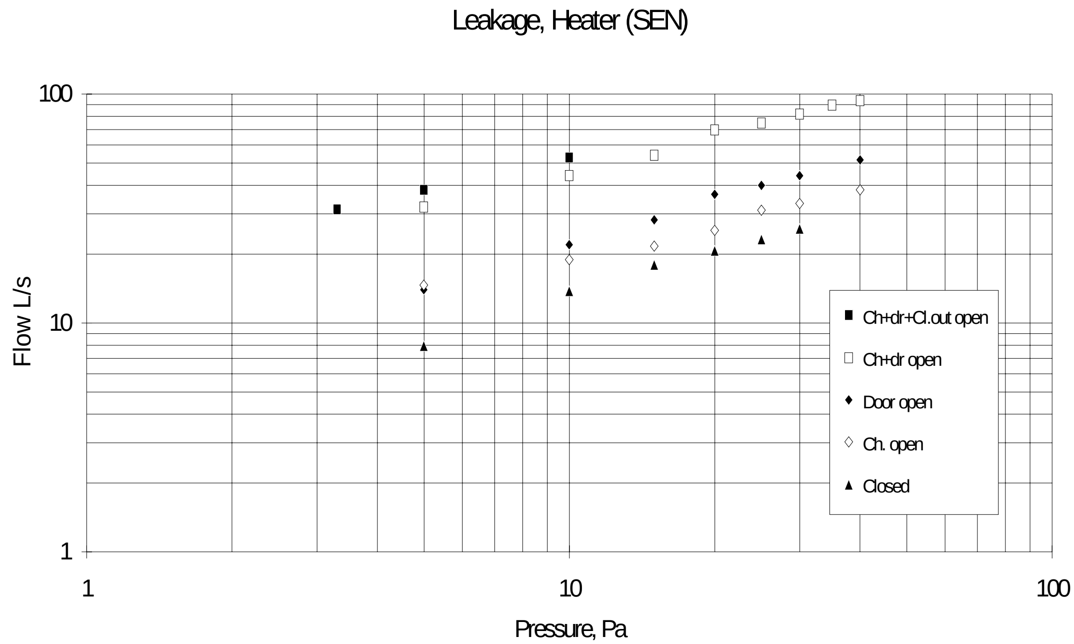
Next, we conduct another tailout test. In this test, we open the chimney damper and the firebox door 12 hours after closure, at 995 minutes. We insert the thermistor sensor from a digital indoor/outdoor thermometer into the chimney at the damper slot, which is located 4 m above floor level. The sensor wire is quite flexible, so presumably the sensor locates itself in the proximity of the flue liner wall. The graph below shows a three hour temperature decay curve from this point.

We see here some very characteristic features of a masonry heating system: With flow re-established in the system by opening the damper and the door, stored energy in the heater is transported by the gas flow into the chimney. The flue temperature in 4 minutes rises from its standby value of 35.6 C to a peak of 45.2. From there it decays with a nearly linear slope of -2.2 degrees per hour. We see an interesting “ripple” in the curve that starts with an overshoot at 4 minutes, a non-linearity due perhaps to the thermistor electronics or possibly due to feedback effects between the airflow and the heat transfer rate in the heater (This is more apparent in the full page chart in the appendix).

At 180 minutes, the airflow with the doors and damper open is 20.6 L/s. We close the damper and the doors, and when we reopen them 13 hours later at 994 minutes, we still see a flow of 20.0 L/s. With the damper and doors left open and a flow of 20 L/s through the system, the decay in the flow over the next 2.2 hours is 0.4 L/s.



Leakage Test: LK-SEN.

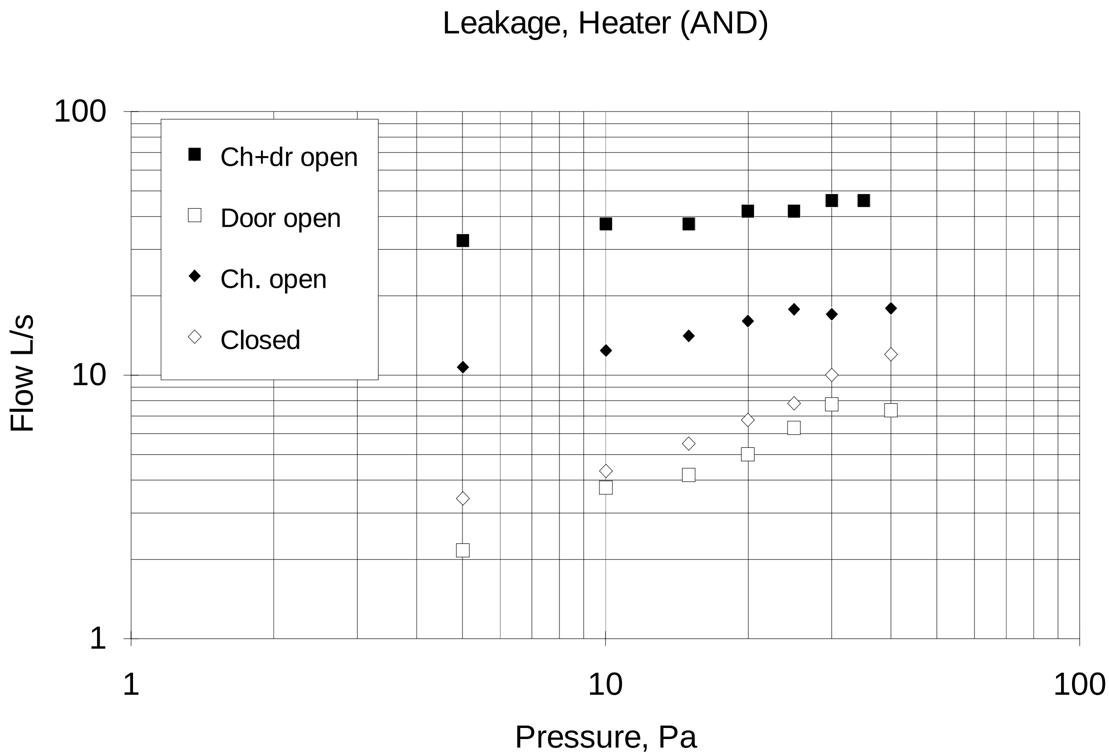


This was a retest specifically aimed at resolving the system leakage question. The air intake was taped closed, and the DTR was taped to the special hood, which was taped to the heater face. The test consists of a series of flow vs. pressure curves taken for a variety of system states: Everything closed, door closed chimney open, door open chimney closed, door and chimney open, door and chimney and chimney clean out open.

The data is summarized quite nicely on a log-log graph of flow versus pressure. At 10 Pa with the doors open we see 22 L/s of leakage. Some of this may be through the chimney damper, which is has a somewhat loose fit. However, we suspect the majority of the leakage to be through the heater core itself, which does not have a “tight” facing.
In order to localize the leakage further, it was decided to conduct a retest on heater (AND), since it wasn’t known at this stage whether the leakage was through the masonry facing itself or through discontinuities in the facing peculiar to heater (SEN).

Leakage Test: LK-AND.
This is a flow vs. pressure test on a representative current masonry heating system. The system consists of a Heat-Kit core and hardware, and a typical 4” clay brick facing. There is a 2 m. heated bench that connects the heater exit with the chimney. There are 3 cast iron clean out doors and a sliding plate chimney damper downstream of the test hood. The chimney damper is tight.

With a complete facing on the core, we see only 3 L/s total system leakage (downstream of the hood) at 10 Pa. The facing is expected to be tight because the space between the facebricks and the core is grouted solid with mortar in this particular system. However, this is not a general practice with brick-faced contraflow heaters. Some systems, for example, provide their thermal expansion control by using a 5 mm mineral wool wrap around the whole core.

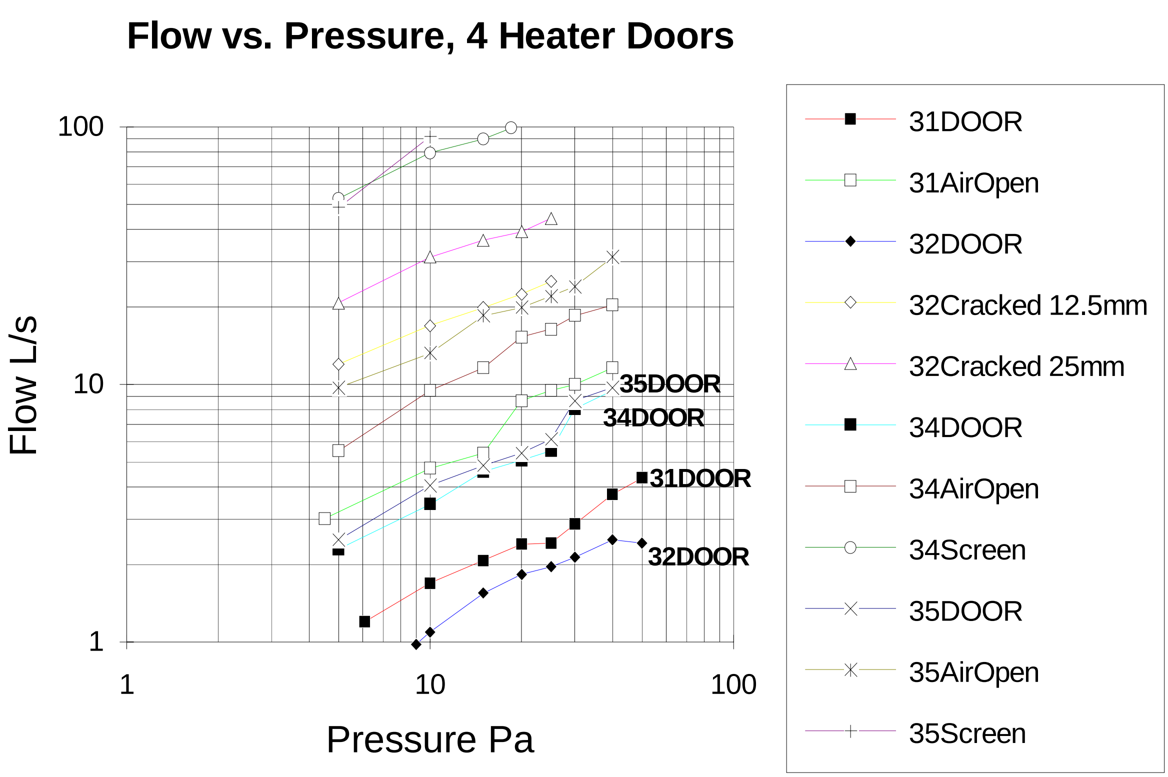


Door Leakage Tests.

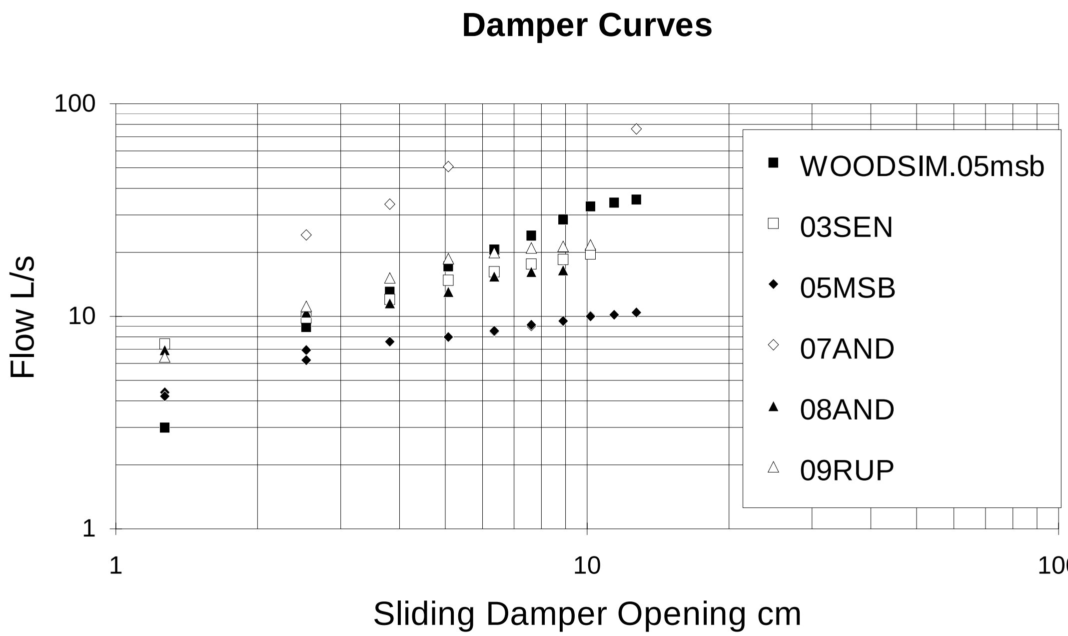
Four masonry heater doors and one cleanout door were tested in a special enclosure built for the purpose. The enclosure itself was first tested for leakage.

All of the doors tested were specifically designed for use in masonry heaters, and are smaller than typical fireplace doors. All of them were of cast iron construction and incorporated a cast iron mounting frame designed to mount onto masonry. All were double doors, and three of the four had ceramic glass. Two of the doors incorporated a cast iron spark screen. Three of the doors were manufactured in Finland by the UPO foundry. The fourth is manufactured in Canada by the author's company. 31DOOR and 35DOOR were gasketed, with ungasketed air controls. 34DOOR was ungasketed and identical to the door on heater 09RUP. 32DOOR was ungasketed and had a machined fit. The same door is used on heater AND. An old prototype for this door is on heater MSB, and a severely abused specimen is found on heater SEN. Specific descriptions of the individual doors are found on data sheets 31DOOR - 35DOOR.

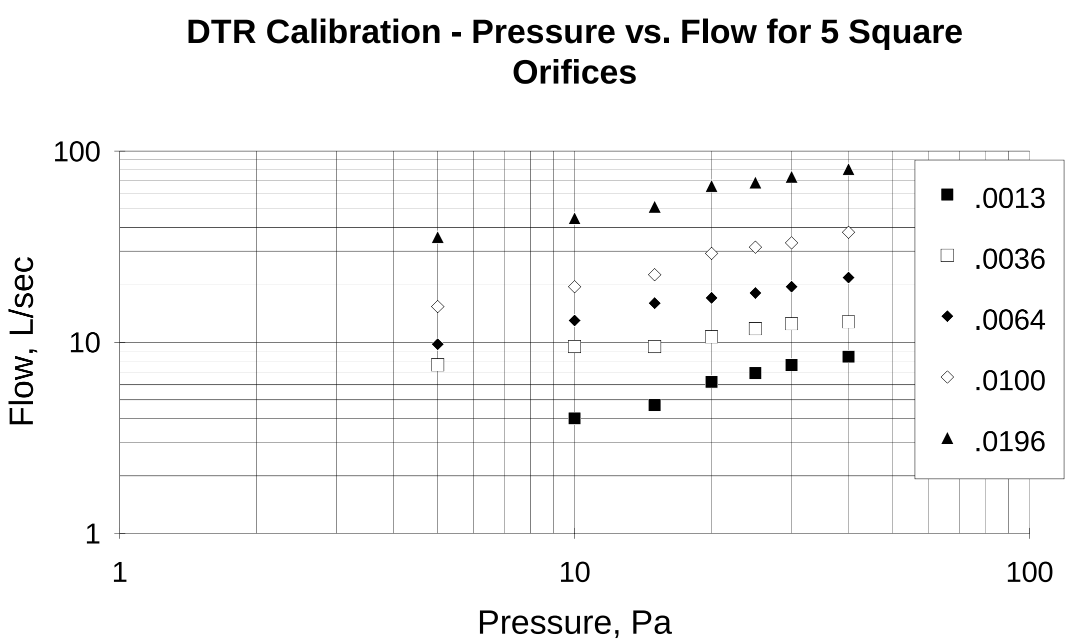
The loosest door tested with its air control wide open leaked 17 L/s at 25 Pa. The tightest door had to be cracked open 12.5 mm in order to leak 28 L/s at 25 Pa.



Chimney Damper Curves.



DTR Calibration.
A sheet of heavy mylar was taped onto a plywood plate with a cutout. A set of 6 squares was drawn on the mylar. Squares were cut out successively with a mat knife and flow vs. pressure measurements taken. The cutouts were later reassembled with tape and retested using the door test enclosure.



A simple check against theoretical values can be done at 10 Pa. Here, the flow equation reduces to A = Q * .0004[xv], where Q is flow in L/s and A is the orifice area in m2. For example, the .0036 orifice is in good agreement with this equation, with a measured flow of 9.5 L/s versus a theoretical value of 9.0 L/s.

DISCUSSION

Air Consumption.
At moderate airflows the dominant parameter governing flow rates in masonry heaters appears to be throttling of the airflow by the combustion air supply orifice. Air consumption for overfire air masonry heaters tested appears to be under 30 L/s for all test conditions. Underfire air heaters appear to be able to consume up to at least 80 L/s. with 200x300 (nom.) chimney flues. By way of comparison, the 1989 Sheltair report[xvi]concludes, for the fireplaces tested, “these fireplaces do not appear to have a high potential for depressurization of a house during their operation. They operate well with a supply flow rate of about 20 L/s, and appear to have a maximum flow rate on the order of 50 L/s for the sizes tested.”

A useful distinction to make in comparing masonry heater and fireplace models is to regard the masonry heater as a fireplace with a heat exchanger interposed between the firebox and the chimney. For example, Sheltair concludes[xvii]that, with an aerodynamically decoupled conventional fireplace, “concentrating all of the *(chimney)* draft on the intake, and directing the intake air to the woodpile creates an uncontrolled “blow torch” effect, seen both in the lab tests and WOODSIM simulations. ” A masonry heater can essentially “fix” this positive feedback problem in a quite elegant fashion.

House Depressurization.
A generally accepted value for HDL (House Depressurization Limit) is 5 Pa. In other words, house negative pressure of 5 Pa or less is not considered to be very likely to adversely affect the operation of most naturally vented combustion appliances.

Appendix A details a simulation run in WOODSIM with a fireplace consuming 30 L/s of room air. The ELA for the model was taken from an actual test of an R2000 house of higher than average airtightness (.015 m2 ELA at 10 Pa). The resulting depressurization was 3 Pa.

It is a common misconception that airtight housing implies poor ventilation. In fact, with mechanical ventilation provided by HRV’s (heat recovery ventilators, or air-to-air heat exchangers), frequent air changes are readily achieved with only a minimal energy penalty. It is interesting to note that a typical HRV penetrates the building envelope with two 125 mm dia. ducts. The “official” ELA used in the WOODSIM simulation was measured with both of these openings taped shut. In fact, the HRV ducts in this example have twice the area of the ELA as it is defined in the R2000 standard.

Outside Combustion Air.
All of the overfire air masonry heaters examined in this study consumed well below 30 L/s of air even at peak burn rates. Based on this data, it one could reasonably conclude that overfire air masonry heaters without outside air supplies do not pose a depressurization threat even in airtight houses.

Masonry heaters are currently bound by the outside air provisions in the National Building Code of Canada. There are several reports in the literature of problems resulting from the use of direct connect outside combustion air in fireplaces. Draft reversal in particular has been cited as a potential safety concern for factory fireplaces with low mass, insulated metal chimneys. Due to the different tailout characteristics (see below) of masonry heaters, it is probable that they can use outside air without major risk.

Tailout.
All of the heaters investigated had chimneys that were inside the building envelope. Tailout was investigated with masonry chimneys. Because of the heat storage in a masonry heater and chimney, draft decay during tailout is essentially non-existent. For example, with a typical overfire burn, there is very little indication from a stack temperature curve when the fire is out. In fact, if the chimney damper is not closed after the burn then heat will bleed convectively from the heater into the chimney until the approximately 50 kW-h of reserve is used up. This is most clearly seen in the air flow rates, which remain nearly constant regardless of conditions in the firebox.

It is likely that masonry heating systems with low mass, insulated metal chimneys will exhibit similar characteristics because of the large energy reserve in the heater itself.

Door Leakage.
A number of masonry heater firebox doors were tested for leakage. Leakage rates at 25 Pa were in the range of 2 - 6 L/s. Leakage data was also obtained on several of the same model doors under actual use conditions.

System Leakage.
North American manufactured masonry heaters typically consist of a core that is site-assembled and then faced with a brick veneer. The effect on system leakage of a brick veneer with solid grout between the veneer and the heater core was demonstrated. System leakage would add to the effective ELA of the heater-chimney system and correspondingly higher air consumption and chimney flows. The core system in a masonry heater requires a method to account for thermal expansion, and this is accomplished in a number of ways by different manufacturers. Ideally one should not have to rely exclusively on workmanship in the veneer for tightness. This might be difficult to control, particularly with masons first making the transition to masonry heater construction. One solution would be to develop standard details that would address this issue. Building codes could address this as well. A performance rather than a prescriptive approach would also be an option: at 20 L/s flow rates for example, actual flue gas velocity can be measured inexpensively with a pitot tube inserted into the chimney damper slot.

CONCLUSIONS

1) Airflow rates of overfire air heaters were low (<30 L/s). Underfire air heaters had higher rates, up to 70 L/s.

2) Air leakage rates for masonry heater doors tested ranged from 2 to 6 L/s at 25 Pa.

3) Masonry heaters are not susceptible to spillage during tailout, as are some other types of woodburning appliances.

4) Masonry heaters with overfire combustion air are suitable for operation in modern, airtight houses, with or without outside air supplies.

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[iii] M.C. Swinton, Residential Combustion Venting Failure - A Systems Approach, Final Technical Report, Project 2, Modifications and Refinements to the Flue Simulator Model, prepared for The Research Division, Canada Mortgage and Housing Corporation, Ottawa, (1987).

[iv] ibid., pp. 9-12

[v] Ref. 2, p. 38

[vi] Ref. 2, p. 41

[vii] The Research Division, Canada Mortgage and Housing Corporation, Residential Combustion Venting Failure - A Systems Approach, various documents.

[viii] Ref. 1

[ix] D. R. Jaasma, J. W. Shelton and C. H. Stern, Final Report on Masonry Heater Emissions Test Method Development, Wood Heating Alliance, Washington, (1990).

[x] S. G. Barnett, Summary Report of the In-Home Performance of Five Commercially Available Masonry Heaters, OMNI 80132-01, prepared for the Masonry Heater Association of North America, Reston, (1992).

[xi] N. Senf, "1993 Lopez Labs Tests", MHA News, (6)3: 26-47 (1993).

[xii] Ref. 7

[xiii] Ref. 10

[xiv] Ref. 10

[xv] S. Moffat, Duct Test Rig, prepared for The Research Division, Canada Mortgage and Housing Corporation, Ottawa, 1988, p. IV - 19.

[xvi] Ref. 1, p 34

[xvii] Ref. 1, p 38

APPENDIX A

WOODSIM SIMULATION OF HOUSE DEPRESSURIZATION

DESCRIPTION:

WOODSIM and FLUESIM[i] are software tools that were developed for CMHC to aid in the study of aerodynamic interactions in a house. A wide variety of chimneys, combustion appliances and house parameters can be modelled.

Using WOODSIM 4.0, a simulation was run with the standard BIS.SPC file included with the program. This simulation of a factory fireplace with doors runs in the 30 l/sec range (normalized to standard pressure and temperature) of flue flow.

Equivalent Leakage Area (ELA) data was obtained for a house that was built to the R2000 standard and known to be very tight for its class. This house was pressure tested as part of the normal R2000 certification process, and found to have an ELA of .0139 m2 at 10 pa., or the same cross sectional area as a 125 mm (5 inch) diameter duct. In order to model this house in WOODSIM, the default flow coefficient in the BIS.SPC file was modified by trial and error until an ELA of .015 m2 was obtained

The following modifications were made to the standard file:

Envelope Characteristics:	change flow coefficient to .009
Fresh Air Gross Area:	change to 0.000

Run Time Controls:

Doors Closed:	change to 200 sec.
Turn on Competing Exhaust Fan:	change to 18,000 sec.
Simulation Stop:	change to 600 sec.

The output file (PRN extension) created by WoodSim for the simulation run was imported into Excel and edited for readability.

Results are summarized below. Of interest are the “chimney flow” and “envelope pressure drop” columns. The envelope pressure drop of interest is after 200 seconds, when the firebox doors are closed. At 600 seconds we see a 3 pa house depressurization resulting from a 30.3 l/sec. flue flow.

MODEL OF THE TRANSIENT PERFORMANCE OF A WOODBURNING DEVICE AND A CHIMNEY IN NON-DESIGN FLOW CONDITIONS
===

PROGRAM DEVELOPED BY: SCANADA CONSULTANTS LIMITED
FOR:CANADA MORTGAGE AND HOUSING CORPORATION
DATE:1984,1986

==
C A S E: WOOD BURNING - bis DATE: 03-22-1994
===

S Y S T E M P A R A M E T E R S
=========================

CHIMNEY/HOUSE BUOYANCY PRESSURE AT STANDBY (PA)	5.6
FIREBOX EQUIVALENT LEAKAGE AREA OF FLOW (m2)	0.026
CHIMNEY EQUIVALENT LEAKAGE AREA OF FLOW (m2)	0.021
E.L.A. OF UPPER OPENING OR OF DOORS (m2)	0
ENVELOPE EQUIVALENT LEAKAGE AREA AT 10 PA (m2)	0.015

FLUE LOCATION	Exterior
CHIMNEY FLOW DIRECTION AT STANDBY	Upwards(.99 M/S)

C A S E: WOOD BURNING - bis DATE: 03-22-1994
==

TIME (SECS)	FIREBOX FLOW (L/S)	DILUTION FLOW (L/S)	CHIMNEY FLOW (L/S)	INC. ENV FLOW (L/S)	ENVEL PRES DROP	FIREBOX EXIT TEMP	MIXING TEMP(C)	MEANFLU GAS TEMP	GAS EXIT TEMP (C)
1	3.1	19.5	22.6	19.7	-3.7	22	22	22.2	22.9
5	23.7	8.2	31.9	25	-5.6	65.5	54.5	35.7	21.5
60	24.4	9.8	34.2	26.9	-6.3	67.1	52.8	44.9	38.9
120.5	25.5	10.6	36.1	28.2	-6.8	72.3	55.8	48.2	41.8
180	27	11.5	38.5	29.6	-7.4	79.9	60.4	52.4	45.5
240	20.6	1.3	21.9	14.4	-2.2	121.3	113.7	84.5	65.1
300	22.5	1.3	23.8	14.9	-2.3	140.7	131.6	92.3	65.3
360	30.7	1.6	32.3	17.6	-3.1	200.6	186.8	144.8	115.8
420	34.8	1.7	36.5	18.6	-3.4	234.2	217.8	172.8	141
480	31.1	1.6	32.7	18	-3.2	198.6	184.9	154.1	129.8
539.5	27.7	1.6	29.2	17.2	-3	167.9	156.6	133.8	114.8
600	28.8	1.6	30.3	17.4	-3	179	166.9	139.2	118.2

S U M M A R Y   T A B L E

OUTDOOR TEMPERATURE = -15 C
INDOOR TEMPERATURE = 22 C

FLOW RATES:	L/S	KG/S	
FIREBOX OUTLET FLOW	28.7	0.022	
DILUTION AIR FLOW	1.5	0.002	
CHIMNEY INLET FLOW	30.3	0.024	
EXHAUST FAN FLOW	81.5	0.1	Note: Fan is turned off during t
NET ADDITIONAL ENVELOPE FLOW	17.4	0	

INDUCED PRESSURE DROP ACROSS THE ENVELOPE = -3.0 Pa <<<<<<<

TEMPERATURES:

AIR TEMPERATURE ABOVE FLAME	449. C
FIREBOX EXIT TEMPERATURE	179.0 C
CHIM GAS T. AFTER DILUTION	166.9 C
MEAN FLUE GAS TEMPERATURE	139.2 C
MEAN FLUE LINER TEMPERATURE	85.9 C

ENVELOPE CHARACTERISTICS:

FLOW COEFFICIENT (M3/(S.PA^N)	0.009
FLOW EXPONENT (--)	0.595
LOCATION OF VCL BELOW CHIM TOP (m)	3.25

FRESH AIR INTAKE TO THE FIREBOX
----- NONE -----

ELA OF THE FIREDOOR

FIREBOX 'DILUTION OPENING' ELA	0.0004 (m2)
THE FIREBOX 'COMBUSTION INTAKE' ELA	0.0046 (m2)
IF THERE IS AN INTAKE GRILL THEN THE DOOR ELA IS THE DILUTION OPENING	0.0004 (m2)
IF THERE IS NO INTAKE GRILL BELOW THE DOORS THEN THE TOTAL DOOR ELA	0.0050 (m2)

[i] M.C. Swinton et. al., Residential Combustion Venting Failure - A Systems Approach, Final Technical Report, Project 2, Modifications and Refinements to the Flue Simulator Model, prepared for The Research Division, Canada Mortgage and Housing Corporation, Ottawa, (1987).

RECENT LABORATORY AND FIELD TESTING OF MASONRY HEATER AND MASONRY FIREPLACE EMISSIONS

Norbert Senf
Masonry Stove Builders
RR 5
Shawville, Québec J0X 2Y0

Presented at The Air and Waste Management Association Annual Meeting and Conference, June 24, 1994, Cincinnati.

INTRODUCTION

Particulate matter (PM) is the current focus of EPA woodstove regulations. Prior to 1991, no field data on masonry fireplace PM emissions existed. Limited work since then indicates emission factors comparable to old technology woodstoves. On the other hand, related appliances known as masonry heaters have produced extremely low emissions in EPA-audited field tests.

Masonry fireplaces have been with us for a long time. Masonry heaters, however, are an unknown technology in North America prior to 1981 and remain outside the realm of the conventional. By contrast, they are a 100+ year old technology in several European cultures, with a penetration in new housing that, in the case of Finland, exceeds 90%. Although they often look very similar to a fireplace they are fired in a radically different fashion. A charge of up to 25 kg of fuel is burned very rapidly and the resulting heat is transferred to and then stored in a masonry mass, from which it is gradually released into the heated space. Typical specs. are 50 kWh of storage and a 2 - 3 kW average output for 18 to 24 hours.

European emissions standards differ from country to country and tend to focus on CO, so we have very little masonry heater PM data. Recent work in North America suggests that the ratios between masonry fireplace and masonry heater PM emissions factors are around 10:1. With the advent of fireplace bans in some Western airsheds, the availability of this established alternate technology merits serious consideration by the regulatory community as well as the masonry and housing industries.

The author and collaborator J. Frisch have conducted more detailed testing on a contraflow masonry heater using a Condar (Oregon Method 41) dilution tunnel and a 4 gas analyzer and have confirmed the results from EPA-audited field tests on 7 masonry heaters.

HISTORY OF TESTING

Background

EPA Regulation. The 1988 EPA woodstove regulation quickly became a benchmark. It defined emissions testing for domestic wood-burning appliances, where previously several proposed testing standards were in the running. While Europe tends to use CO to define clean combustion, PM, specifically EPA Method 5H (EPA-M5H) PM, is now the name of the game for anyone wanting to sell woodstoves in the United States. At the same time, woodstoves were defined rather narrowly to exclude fireplaces, masonry heaters, cookstoves and furnaces from the regulation. Also, burn rate is measured by putting the appliance and its venting system on a scale, making it for all intents and purposes unusable for high mass appliances to the required accuracy.

It soon became convenient for regulators in Clean Air Act non-attainment areas to mandate the use of EPA certified appliances in SIP's (State Implementation Plans) as one strategy for reducing PM emissions into the airshed. Some clean appliances, such as masonry heaters, were uncertifiable under the EPA woodstove definition. Builders of masonry heating systems first encountered a problem in the state of Washington. A homeowner could not use his $10,000 masonry heater on a no-burn day, unlike his neighbor with a $500 EPA woodstove. Ironically, the EPA reg. itself states the following:

> "The 800 kg. cutoff was established as an easy means of excluding the high-mass fast-burn wood-burning appliances ... (which) typically operate at hot, fast burn rates and cannot be damped. It is also likely that they are incapable of meeting the 5 kg/hr minimum burn rate. The intent of the committee was to exempt from the standards these appliances which rely on clean-burning air-rich conditions and which have high combustion efficiencies. It should be noted, however, the exclusion does not apply to appliances which exceed the 800 kg threshold only because of masonry or other materials which are not sold by the manufacturer as integral parts of the appliance."[i]

Washington State members of MHA (The Masonry Heater Association of North America) negotiated with the State, and the Department of Ecology agreed to grant an exemption for masonry heaters that could prove their cleanliness claims. An immediate problem became evident: the lack of particulate emission data for masonry heaters. The bigger challenge however, was that in 1988 there was no recognized test method for obtaining PM numbers in either masonry heaters or masonry fireplaces.

Laboratory Methods

Colorado Fireplace Report. The only relevant prior work was the Colorado Fireplace Report[ii], published in 1987 by Shelton Research. Most of its work revolved around establishing a fueling protocol, and I will attempt to demonstrate that this is really the main issue in masonry heater and fireplace testing.

It was self-evident that the fuel load defined in the EPA standard is inappropriate for fireplace emissions testing. Particularly in larger fireplaces, the load was deemed "unrealistically large, dangerous and impractical." A 36" fireplace would require a burn rate of around 37 kg/hr. Shelton suggested a fuel load and protocol involving the addition of single log loads at a fixed time interval to achieve a pre-selected fueling rate. Testing conducted during the kindling phase led to the conclusion that hot-to-hot tests would not distort the relative ranking of the appliances studied. One benefit of this scheme was that it was equally applicable to factory-built and masonry fireplaces, since the appliance does not need to be weighed. A masonry fireplace is essentially unweighable at the 0.1 lb resolution required in the EPA stove protocol, particularly in view of the hygroscopicity of masonry materials. Most of the test series was used to develop the fueling protocol and make the fire look realistic. The actual protocol itself was used for only a few tests at the end of the project.

WHA/FERC (Fireplace Emissions Research Coalition) Report[iii]. In 1988 Washington State members of MHA in association with WHA (Wood Heating Alliance) persuaded both the masonry and the factory fireplace industries that is was in their interest to proactively help fund the development of an emissions testing protocol for fireplaces. A masonry heater protocol was included in the project as an example of forward thinking masonry fireplace technology.

In the FERC project, fireplace fueling protocol work was continued at Shelton Research using factory fireplaces. At the VPI (Virginia Polytechnic Institute) Combustion Lab in Blacksburg, MHA built a 30" and a 36" masonry fireplace as well as an underfire and an overfire air masonry heater, along with masonry chimneys. Underfire air is characterized by combustion air supplied through a grate in the firebox floor. Fueling protocol again became the main issue in testing design. A stated objective was that "the most important aspect of the laboratory test method is that its results correlate with field results."[iv] The main debate was between real world fuel on the one hand and laboratory repeatability on the other. With the masonry heaters in particular, there was no prior North American testing base. One of the elements at the start of the study was interviews with industry experts to survey existing practice. VPI used a modified EPA 5G dilution tunnel, and sampled PM in accordance with EPA-M5G.

Results: A total of 35 test runs were done on the masonry heaters. Of the 17 fireplace tests, 5 were done on the masonry fireplaces. Different average daily burn rates on the masonry heaters were arrived at by varying the firing interval. There was an order of magnitude difference between the masonry heaters and the fireplaces. Test results are summarized in Table 2.

Field Methods

VPI. In the WHA/FERC study the VPI woodstove sampler, already in existence, was used as a basis for an initial masonry heater field sampler design. Development of the field sampler began in 1989, along with the development of the draft standard laboratory test method. Parallel testing was conducted and analyzed, but it was concluded that the PM correlation was not acceptable and that further testing was needed. VPI also developed a fireplace field sampler during the study[v], and acceptable correlations were demonstrated between field sampler and dilution tunnel PM and CO numbers.

OMNI Environmental. In 1990 regulatory activities against fireplaces in Fresno California got Western States Clay Products Association interested in obtaining some baseline field emission numbers. EPA was using 14 grams per kilogram, and they wanted to see if it was accurate. OMNI Environmental was commissioned to do a study. Masonry heaters were added because they looked promising, and Rosin and Rumford fireplaces were included as well.

MHA members were very fortunate, after the study, to meet the late Dr. Stockton (Skip) Barnett. MHA arranged for OMNI to set up a 2 day course with the title "Short Course on Masonry Fireplace and Masonry Heaters Emissions Testing Methods and Combustion Design[vi]." The course took place in October 1991, a year before Dr. Barnett's death. It marked a turning point in our understanding of masonry heater performance issues - Dr. Barnett was uniquely qualified to give us an informed and broad overview of the testing and emission questions that we were puzzling over at the time. Most of the attendees were stovemasons, people who are hands-on, and Dr. Barnett's down-to-earth style allowed him to transfer a great deal of information directly to where it was needed.[vii] Dr. Barnett stated that the study was designed to come up with information that would be most beneficial in the regulatory arena so that regulations could be developed so that all stakeholders could be most fairly treated. The research was not concocted to portray an industry point of view.

The AWES method. The methodology involved the AWES (Automated Woodstove Emissions Sampler), developed by OMNI and in use for six years. It was used in all but one of the major woodstove field studies done since 1985. Essentially it is an automated system that detects when the appliance is being fired, samples the stack gases continuously and captures the PM in filters and a sample bag which are then brought to a laboratory for analysis. In addition, a computer generates gas curves that provide additional information about combustion conditions in the appliance over a one week sampling period. Most importantly, a reliable bridge has been established between AWES PM numbers and EPA Method 5H (EPA-M5H), which is the reference method used for woodstoves.

Dr. Barnett stated that the primary goal was to establish a baseline factor for conventional fireplaces. He told us that there had been NO fireplace studies done in homes in which there's been burning conducted anything like the way homeowners burn, that the literature was empty in this regard. There had been no studies of fireplaces, let alone masonry fireplaces and therefore no baseline. The baseline is required by the SIP's (State Implementation Plans, required by the Clean Air Act). He explained SIP's try to project into the future an attainment scenario, and that this is founded on the baseline. Then, if technologies are identified that reduce emissions by a certain percentage, emission reductions can be addressed and quantified. A second goal was to measure emissions from some advanced fireplace designs that were available such as the Rosin aerodynamic firebox.

The emissions factors on conventional fireplaces came in substantially higher than the VPI lab. numbers. See the summary of test results in Table 2. On the other hand, a database was established on how fireplaces are burned. Instead of being burned around the clock like woodstoves, fireplaces tend to be burned 3 1/2 to 4 hours per day instead. A good baseline was developed, with over 350 hours of burning. There was also good news on alternate fireplace designs. One of the designs studied was the Rosin firebox. It was developed in 1937-39 by Professor P.O. Rosin for the British Coal Utilization Research Association[viii]. Rosin built extensive fluid models and used dye tracking techniques and dimensional analysis to study air flow patterns in open fireplaces. OMNI studied two Rosin installations. One was an original equipment model. For the second one, they monitored an existing residential masonry fireplace for a week with the AWES. MHA members then retrofitted a Rosin firebox and the monitoring was repeated. The Rosin aerodynamic firebox got a 50% reduction in emissions[ix], both as original equipment and as a simple retrofit. Dr. Barnett summarized for us the potential for airshed improvement as follows:

> If you take a look at a community like Reno or Fresno and you ask "what's it going to take, what can you do, to reduce emissions from fireplaces?". Well, we can go out and sell new fireplaces, but every one that we sell, we're going to add to the level of emissions in the air. What's the key? It's getting rid of the established base of fireplaces. This has been a big job, because its easier to support with woodstoves. I submit that fireplaces are going to be a lot harder to get rid of. They're not going to move. But you have the opportunity to go into an airshed, and I think this is a big bargaining chip, and say that for every Rosin we sell we can reduce that house's emissions by 50% right of the bat.

The study for Western States Clay Products also included in-home tests on 2 masonry heaters.[x] One heater was an early home-built one, and did not get very good numbers. The second one was the same model underfire contraflow heater tested at VPI. PM with cordwood fuel was reasonable at 5.6 g/kg, and about double the lab. results on dimensioned lumber fuel.

After the VPI laboratory tests and then the initial OMNI field tests, a consensus was emerging in the masonry heater community that underfire combustion air deserved a more critical appraisal. It was introduced from Europe in 1985[xi] and widely adopted in contraflow heaters, and there were indications that PM emissions performance was questionable vis-a-vis heaters with overfire combustion air. We had also seen results from tests that CCRL (Carbonization and Combustion Research Laboratory) of EMR (Energy Mines and Resources) Canada had done on an underfire air contraflow heater in an advanced demonstration house that indicated excess air levels of 1000%, with resulting overall efficiency in the 40% range.

During the OMNI workshop in Oct 1991, MHA was more or less shopping for test methods. Laboratory testing was very expensive, and was unaffordable for small companies often consisting of individual heater builders. Moreover, while valuable work was done in developing a testing method, there were still a lot of unanswered questions about how realistically the dimensioned lumber fueling protocol reflected actual everyday use. One of the valuable things about the initial AWES tests was that it demonstrated that real world masonry heater use was a lot different from wood stoves. The heater tends to get fired the same time every day, with the same fuel type and stacking. The burn progresses pretty much in an identical fashion from day to day. This provides something to capitalize on. Masonry heaters essentially do an end run around several performance issues that metal stoves have to deal with - smoldering at low burn rates, preheated secondary air carefully tuned to each firebox type, etc. The suspicion was that most masonry heater PM originates during the cold start and that the rest of the burn is probably pretty clean.

Regulatory Issues. As the fledgling masonry heating industry faces regulatory issues day in and day out, this is proving to be the biggest challenge - convincing regulators who are completely unfamiliar with this product, which has been in use in Europe for more than 100 years, that it is fundamentally different from airtight stoves and therefore unfair to tar it with the same brush. So the onus is on the industry to prove its point. Since M5H PM has only entered the picture relatively recently, we are unable to go to the database of existing testing in Europe.

Immediately after the OMNI Workshop MHA decided that a good first step would be to extend the AWES database, which so far consisted of a bad homebuilt Russian heater and an underfire air heater, which was actually pretty representative of the majority of heaters getting built in North America in 1992. An AWES test was funded on the second model tested at VPI, which was a handbuilt overfire air heater[xii]. At the same time, AP-42 and BACM[xiii] were in the works and it was starting appear that field testing would be the name of the game for any kind of alternate EPA recognition of so-called non-affected facilities which fell outside of the regulation and were therefore uncertifiable by definition.

To date a total of 7 commercially available masonry heaters have had a one-week in-home AWES test consisting of 7 burns each. In addition, MHA funded OMNI's share of an EPA audit of the Masonry Heater In-Home Test Method. The fuel protocol that EPA insisted was strict: the homeowner uses his own fuel, and is not allowed to get any coaching whatsoever. Interestingly, when the technicians from the auditing company were witnessing the beginning of one of the burns, they ran outside, didn't see any smoke, and assumed that the fire had gone out. Apparently they had never seen this kind of phenomenon before. And, in fact, this is the main challenge facing builders of masonry heaters today - trying to inform regulators about masonry heaters and being taken seriously.

There was some debate as to how to report the overall AWES field results because of an emerging underfire/overfire split. There were three contraflow heaters and four other masonry heaters of various origins. One of these was the same handbuilt overfire unit tested at VPI (.99 g/kg) and it came in at 1.4 g/kg on cordwood. The overall average from 49 total days of use (one must be careful here and define "use" as when the stove is heating the house and not just when it's burning fuel) is 2.7 g/kg, and the AP-42 number is 2.8 g/kg. Together with the VPI tests and with the Lopez tests that I will present shortly, this is it all of the EPA M5H-compatible masonry heater data to date. A common reaction from regulators is one of skepticism, based on unfamiliarity with the fundamental concepts of high mass appliances. To reiterate, masonry heaters are characterized by a single, high, burn rate combined with heat storage.

There is, in my opinion, more to this data than first meets the eye. PM factors (g/kg) for seven heaters were as follows: 5.7, 5.6, 2.9, 1.9, 1.9, 1.4, and 1.4.[xiv,xv,xvi] The 5.7 and 5.6 were the two underfire air heaters. The 2.9 was from a heater described in its report as a combination of underfire and overfire. So my contention would be that what we see here a is bipolar distribution with the break based solely on whether the combustion air comes up through a grate or not. The changeover from underfire to overfire air is fairly simple. As a matter of fact, we developed a five-minute retrofit for the Heat-Kit system that we tested at Lopez and at VPI and with the AWES. The retrofit would certainly make for an interesting AWES re-test. Based on our Lopez testing, I would expect to see a 70% PM reduction from 5.6 to 1.6, plus or minus .5 g/kg. If we take out the 2 underfire heaters and leave in the 2.9, then we get 1.9 g/kg overall average for 35 days on 5 heaters. Interestingly, if one compares the emissions factor ratio between underfire and overfire, for the dimensioned lumber fuel protocol (VPI) it is 2.8, for the AWES it is 3.0, and for the Lopez testing it is 3.7. As mentioned, underfire air is a bit of an anomaly, and now is one more thing complicating our relationship with regulators. We can live with 2.8, and can arguably claim that this is a conservative scenario.

European Testing

Outside of North America, the most organized testing effort right now is being conducted in Austria. In Austria there is a Stovemason's Guild, and it is several hundred years old. The Austrians arguably build some of the best masonry heaters in the world today. They don't bother much with metal stoves, and you wouldn't sell a single gas log over there. The Stovemason's Guild has its own testing laboratory with Dr. Herman Hofbauer as their chief researcher.

Emissions and clean-burning in most of Europe tends to be defined in terms of CO, lack of which is used as an indicator of good combustion and hence low emissions. So, based on CO, Austrian stovemasons have undertaken a very extensive multi-year research project. MHA has published a report on it.[xvii]The first thing that they did was a nation-wide series of in-home tests to establish a baseline of the existing stoves. Most of them were clean, but a few weren't. The Guild is very pro-active in exercising its mandate of controlling masonry heater design standards, and if it finds that some particular firebox style tends to burn dirty then it simply isn't allowed to be built anymore. North American clean air authorities could profit from this approach and consider delegating responsibility for masonry heater emissions performance to, say, a high quality industry certification program. Presumably we can all agree that net environmental impact is the real issue here.

In the next project, the Austrians studied operator influence on masonry heater emissions. Basically they looked at how big the wood load was, vis-a-vis the design load, and which ignition method was used.

Burn Rate. This brings up a key concept for masonry heaters - burn rate. This is really the point of departure from conventional woodburning devices, in the following way: Burn rate is not controlled. Heat storage ability is what makes burn rate control unnecessary. Burn rate is calculated in a simple manner. For example, if 20 kg of fuel is burned over two hours, then the burn rate is 10 kg/h, averaged over two hours. Ten kg might only take 90 minutes, so the burn rate would be 6.7 kg/h.

What the Austrians did was very clever. They calculate a maximum design burn rate, ie., wood load, for a given size firebox. Next, they measured CO versus burn rate by using different wood loads and found that there is an optimum burn rate region. If the optimum burn rate region is exceeded, then fueling practices which slow the fire down, such as igniting the load from the top instead of from the bottom, result in a CO improvement. Similarly at the low end. If the wood load is very small then it is advantageous to light it from the bottom in order to increase the burn rate. It would probably be desirable to split the wood smaller as well. In between these two we see a fairly broad optimum burn rate region. An unexpected finding was that in the optimum region, it doesn't matter whether the charge is kindled from the top or the bottom.

The Austrians haven't studied wood sizing or moisture yet, but they intend to. One can reasonably expect that splitting the wood finer should result in a faster burn rate, and that using wetter wood will slow it down. So, the Austrians use the burn rate concept to interpret their emissions results, ie., CO. It is somewhat removed from PM factors and rates.

Condar (Oregon M-41) Method at Lopez Labs

The Condar dilution tunnel method was used at Lopez Labs to measure particulate emissions. Developed by Dr. Barnett, it is a very simple system. It is a dilution tunnel, but of an interesting type. A sample probe extends about 1/2 inch into the stack, from which the gases immediately enter a 6 inch diameter cylinder which is attached to a pump. In front of the pump is a filter. The dilution is provided by a series of 24 holes drilled into the face, providing a dilution ratio of approximately 20:1. The orifice is calibrated, and the motor is regulated to provide a constant pressure of around -0.1 inches of water. The regulated pressure insures a constant sample flow. As the filters load with particulate, a Variac control is used to run the motor harder to compensate. The temperature after dilution is under 90 degrees F. The Condar design allows real-time monitoring of emissions simply by pulling the filters at anytime and weighing them.

What the Condar is not, like the AWES is not, is an official EPA method. It is not a Method 5. However, it was approved by Oregon and is known as Oregon Method 41. The Condar has been used to develop, interestingly enough, the very cleanest burning woodstoves. They have all come through this method of evaluation. As Dr. Barnett explained "the reason is that it is extremely fast and extremely reliable. All the other techniques, as used on location by manufacturers, have proved to be too slippery. They're too scientific, too technical, too fidgety. So, they've been a problem, but this one is not. We used to take this one around to 5H locations and got the same relationship between this one and 5H. You can't do that with a dilution tunnel. You probably can't even do it with 5H and 5H."

In Barnett's spreadsheet formulas for the Condar, there is a conversion factor between a Condar PM factor and Method 7. We chose not to apply this conversion - for two reasons. First of all, about half of our PM is non-soluble, probably soot and fly ash, and we would expect the filters to capture 100% of that. Secondly, the correlation work with the Condar was done with conventional woodstoves, and there was no work done at the low end of the PM scale.[xviii] As an example, 4 g/kg Condar converts to 6 g/kg M-7 equiv., which is a 50% increase; at 27 g/kg. they are even, and above 27 g/kg the M-7 is lower.

Organic Compounds and PAH's. Barnett also went on to talk about organics. Recent major studies with pellet stoves have shown that pellet stoves have pretty much gotten their organic fraction down. Masonry heaters have the responsibility to do the same. The Austrian Stovemason's Guild commissioned the Austrian State Institute for Testing of Synthetic Materials to do a study of masonry heater PAH's in 1985,[xix] and they arrived at a value, under good combustion conditions, of 20 $\mu g/Nm^3$.

This is near the low end of the values found in 2 pellet stove studies done by OMNI in 1990[xx,xxi].

After the OMNI workshop in October 91, MHA consensus was that it was not possible to base low PM masonry heater design on CO testing. Soon thereafter my collaborator, Jerry Frisch, located and purchased a complete Condar[xxii] dilution tunnel setup, complete with analytical balance, and a SUN SGA-9000 four gas digital analyzer designed for automotive emissions testing.

Since some of the cleanest woodstoves were developed with the Condar, we sought advice from several stove manufacturers who were experienced in its use. We set up Lopez Labs at Jerry's shop near Seattle in the spring of 1992 and spent about 10 days doing test runs on an underfire contraflow heater. We were basically working out the bugs.

We did a 24 day test series in the spring of 1993. We had three appliances hooked up to the chimney and could switch them in and out with a special damper setup. We had a small underfire contraflow heater that was donated by one of the manufacturers. We had a Rosin fireplace with doors that Lopez was doing development on. And we had a large modular contraflow heater which we used for the testing that I would like to describe here.

This heater, a Heat-Kit, was one of the two units originally studied at VPI and also one of the two heaters in the first AWES tests. So we have an EPA-audited field number and a VPI laboratory fueling protocol number on it with underfire air. It was also the first modular system to be developed in North America, and is probably a good representative of the majority of heaters built here from about 1985 on. It could be termed a North American generic brand (ie., large) contraflow heater.

A parallel debate with regulators is the emission factor versus rate question, ie., g/kg of fuel or g/hr. The EPA reg. uses g/hr, but an implicit assumption here is that the appliance has to burn fuel while it is giving off heat. If a 2 hour burn in a masonry heater supplies 24 hours worth of heat, you will obviously have a concentrated PM rate, g/hr, for 2 hours. In terms of net environmental impact, I would submit that the real issue is the total daily emissions compared to a certified appliance. Since my stove stores heat and therefore has no fire on for 22 hours out of the 24, we can only make a non-trivial emissions comparison based on a <u>factor</u> instead of a <u>rate</u>, ie., g/kg of fuel burned. If we both burn equal amounts of wood then our net environmental impact, on average, will be the same with the same PM factor. An alternate formulation is to use a 1 kg/hr nominal burn rate, averaged over 24 hours. In fact, this is very near the average burn rate of the average wood stove. g/hr @ at 1 kg/hr equals g/kg, of course.

This issue was cast in stark relief in Colorado recently. When the Colorado Air Quality Control Commission looked at the OMNI data, they saw a Royal Crown heater at 2.0 g/hr and a Heat-Kit heater at 51.7 g/hr. and concluded that masonry heaters as a class are not clean burning. How can a 51.7 g/hr heater possibly be clean? Colorado would not buy the heat-storage argument, so our job became one not only of documentation, but also of education. Of course, if we take EPA's AP-42 field number for all Phase II woodstoves, at the Heat-Kit's .75 kg/hr average daily burn rate we would get 133 g/day, for the average Phase II stove. To compare that with the Heat-Kit, we have to squeeze it into two hours, yielding 66 g/hr. So our <u>dirtiest</u> heater is 20% cleaner that the <u>average</u> phase II stove, according to EPA's own field data. Although we have landed a man on the moon, we have only recently learned to abolish underfire air, yielding a further 60-70% reduction. I will now attempt to show that the Lopez data indicates, as does the OMNI and the VPI data, that in fact only one variable, the generic air system, separates Colorado's 52 g/hr monster from the cleanest domestic-scale cordwood burning device in existence. A spin-off is that we now have the largest PM emissions database on the Heat-Kit of any masonry heater.

Almost anyone who is new to the field of masonry heaters will invariably assume that they need to be complicated. In reality, a heater is functionally just a refractory firebox with some air, and some extra flue runs on the way to the chimney. In fact, about half of the heat transfer takes place in the firebox itself. Four feet out of the firebox, there is not much heat left to exchange. The heater is run wide open, throttled by the fixed air inlet. Too large an air inlet results in more excess air than necessary. Too little and you don't get a clean burn. Again, heat storage and burn rate independence are two sides of the same coin, and they simplify things enormously when you burn cordwood. You can get 1.5 g/kg PM without getting fancy. However, building a heater that doesn't fall apart from the constant thermal shock is an entirely separate matter.

I will now describe the 23 day Lopez series. Table 1 is a summary of the raw data. On the first run there were still equipment bugs, so it was discarded. On the last run #23, we only have preliminary (undried) filter weights. There is also a filter problem on run #17, evident in a very low PM number. So 3 runs are discarded for mechanical reasons. The raw data is everything else.

The bulk of PM occurs at startup. To duplicate field conditions, firing is conducted on a 24 hour cycle. Twenty four hours are required for the firebox to cool off, otherwise PMs will drop because of the warmer start. Since the chimney and appliance are in an unheated part of the lab, they are actually a little cooler after 24 hours than in the field. In a house the firebox would be at around 150F after 24 hours.

Being limited to 23 tests, parameters were chosen carefully. We did repeat runs in three cases. Our main job was to change the air system on the heater over from underfire to overfire. We had enough data from 1992 that we didn't use up too many runs on underfire air. Only run #18 is a true underfire air run, ie., the previous standard air system used at VPI and OMNI. We got 6.3 g/kg and OMNI got 5.6. This air system was used on all contraflow heaters between 1985 and 1982, both here and abroad.

Fuel Protocol. Our fuel protocol was as follows: We had 16" old growth Douglas Fir cordwood all from one tree. We measured every piece for moisture and for many runs also measured circumference so that surface area could be calculated. We used pretty much the same stacking scheme on every run, and photographed every load. We started out with smaller, European style loads and from run #9 on switched to larger loads more typical of North America. We also used, compared to the Europeans, fairly large pieces of wood more typical of what we see in the field. On 4 runs, we took the wood load and split every piece in half, to see the effect of increased surface area. Finally, we kindled the load from the top instead of the bottom, because we had reason to believe that this results in a cleaner start.

For a baseline we started with no air supply except for cracking the door a quarter of an inch. This is run #2. It should also be mentioned that there was a section of single wall chimney that got insulated starting with run #3. Recent tests by the author on masonry heater air consumption lead us to suspect a leak in the masonry, which would account for our fairly high oxygen numbers. This has no effect on the calculated PM factors except for a loss of some precision in the oxygen readings as they approach ambient.

With the Condar we had a PM number in 24 hours. Each morning, after examining the data a single change would be made in the air supply. These are described in the published results.[xxiii,xxiv] When viewing the graphs in Figures 2, it is useful to know that there is a progression in the runs, from a baseline run #2 to a fairly optimized run #19, with a few detours in between.

Results. Table 2 is a summary of our results. It also provides a comparison of, essentially, all comparable PM testing that has been done on masonry heaters and fireplaces. In arriving at the Lopez averages, the following rationale was used: The overall average is the average of all the raw data, adjusted as described above. We are confident that there is a bipolar distribution between overfire and underfire air, and accordingly this is our categorization. Our underfire factor is from one test, #18.

The corrected numbers are derived as follows: On the gas curves, it is readily apparent that when the pieces are split in two for run #4, the CO has a huge double spike at startup because combustion conditions in the fire box are too fuel-rich. PM's quadruple to 4.9 g/kg. Run #5 is a repeat of run #4, for verification. The numbers change somewhat, but the double spike geometry remains intact. For run #6 we increase the air supply from 2 to 4 sq. in. and raise the wood moisture 3 points, and things settle back down. There is a similar occurrence on runs #15 and #16. This is evidenced in the fuel piece count, which is the highest of the whole series at 16 pieces for both runs. The Austrian stove builders have a term to describe what I believe happens here. It is "Umkippen der Verbrennung", literally a "tipping over, or loss of equilibrium, of the burn." A contemporary terms might be "non-linear". To get what we term the corrected overfire air number we throw out runs #4,#5 and #15,#16. It is a straightforward matter to ensure that masonry heaters have a proper air supply, because the homeowner doesn't control that air supply, but simply lets the wood burn at its own speed. The Austrian research teaches us that if the fuel load is large and the burn rate needs to be reduced, top ignition can be used.

Sampling**.** The Lopez PM sampling scheme uses the Condar with two back to back filters. The filters are changed at 15 minutes to allow separation of the startup effects. Chart 2 shows a plot of the 15 minute PM, in terms of filter catch, as a fraction of the total catch. The 15 minute filter catch is about 40% of the total, on average, even though only a very small fraction of the fuel has actually been consumed. A real world scenario for this size heater is around 2 - 3 kilowatts output over 24 hours from a 20 kg (dry basis) charge. Approximately 12 out of a total of 30 grams of PM for that airshed over 24 hours are emitted during one 15 minute interval.

Soluble Organic Compounds. OMNI measured the soluble organic fraction in one of the overfire AWES series and it was 39%, ie., a 1.4 g/kg heater emitted 0.5 g/kg of soluble organics. So typical soluble organic PM emissions appear to be in the area of 12 grams per day for large overfire heaters fired on a 24 hour cycle.

CO. One of the questions that we had, and this would be my main question with European test methods, is whether overall CO is an indicator of PM. Figure 1 is a plot of CO Factor against PM factor for 20 cordwood runs at Lopez, 30 dimensioned lumber runs at VPI, and 49 days of in-home testing by OMNI on cordwood. We don't see much overall PM:CO correlation at the low end of the PM scale, although there is some interesting clustering in some of the sub-groupings. In the OMNI field tests, the heater with the lowest CO factor had the highest PM factor, which may explain why there is a discrepancy with certain European research.

HC. Of interest on the Lopez gas curves, in PM terms, is the HC curve. This is hydrocarbons as measured on an automotive emissions analyzer, which is calibrated on propane. Chart 2 shows a plot of the 15 minute HC fraction together with the 15 minute PM fraction. There appears to be a relationship. Also plotted is the ratio of filter catch to total HC, which is taken as the area under the HC curve.

PM. The final item plotted on Chart 2 is the PM factor for the runs which we defined above as overfire, ie., four runs are removed as outlined. I submit that this is a reasonable approximation of what we would expect to see in the field, because essentially we've exposed the stove to 19 runs over a much wider range of air systems than would ever be seen in actual practice, and then discarded 4 runs that have literally gone "over the edge."

CONCLUSIONS

PM testing on masonry heaters and masonry fireplaces has started only recently, so the database is small. Standard masonry fireplaces with large openings and correspondingly large flue diameters are essentially no different from open campfires and have PM factors similar to those of conventional woodstoves. Simple retrofit technology exists that appears to be able to substantially reduce the airshed impact of the existing installed base of masonry fireplaces and deserves further investigation.

Current PM data on masonry heaters is limited but consistent. While PM emissions with a dimensioned lumber fueling protocol are about half those of field-test values, there is a consistent bipolar distribution of PM factors based on whether there is combustion air through a grate. The ratio between overfire and underfire PM factors is consistent across fueling protocols used so far. With masonry heaters restricted to the use of overfire air, EPA-audited in-home particulate emissions for 5 different masonry heaters totaling 35 days of use averaged 1.9 g/kg. These are the among the cleanest numbers ever recorded for cordwood burning appliances in the field and appear to be equal to or better than results for EPA Phase II pellet stoves.

Regulation. One of the greatest challenges facing North American masonry heater builders today is to educate clean-air authorities about their potential. Burn rate independence is the most important concept to get across. It permits combustion design for masonry heaters to follow simple, long-established rules. This permits qualified builders to site-build a wide variety of custom appliance configurations. With AP-42 recognition from EPA, the author feels that is inappropriate to willy-nilly subject a site-built appliance with a demonstrated path towards low-emissions assurance to regulations designed for mass-produced factory appliances. With an expanding emissions database, there appears to be little reason to fear crossing the bounds of good combustion design, since finely tuned secondary air systems are superfluous. Trade certification, based on the Austrian model, may be an appropriate regulatory mechanism.

I would close with the contention that cordwood is a clean fuel. With a heat storing appliance that does not depend on burn rate control by means of throttling combustion air, we have demonstrated prolonged operation in the field at around 1.5 g/kg PM, and indications are that the soluble organic fraction is in the 40% range. If the cordwood fuel is at the same time obtained through sustainable forestry practices, then we achieve the additional benefit of a zero net CO_2 contribution to the atmosphere.

ACKNOWLEDGMENTS

All North American masonry heater builders owe a debt of gratitude to the late Dr. Stockton G. (Skip) Barnett of OMNI labs, who pointed us in the right direction on combustion testing and design. Many of us knew him only briefly, but his spirit lives on in cleaner air everywhere. Tom Stroud got the ball rolling in Washington State. Dr. Dennis Jaasma and Jay Shelton pioneered the field of fueling protocols for high-mass appliances. Rick Crooks from Mutual Materials initiated the original AWES study for Western States Clay Products Association. When the chips were down and we needed more PM data, long-time heater mason Jerry Frisch put together Lopez Labs out of his own pocket. None of this work would have happened without the Masonry Heater Association of North America, which has served as the front for many a worthy endeavor hugely out of scale with its size. The heater masons across the continent who pay their dues every year are the lifeblood of the organization.

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Table 1. Summary of 21 contraflow heater PM emissions test runs using Oregon Method 41 (24 hour burn cycle).

RUN No.	CA-02	CA-03	CA-04	CA-05	CA-06	CA-07	CA-08	CA-09	CA-10	CA-11	CA-12
Av. Stack Temp	112	133	126	180	171	269	252	312	298	249	274
Av. O2%	16.4	17.0	17.2	16.9	17.4	18.4	18.0	17.0	17.6	18.4	17.9
Av. CO%	0.21	0.11	0.35	0.21	0.10	0.05	0.07	0.06	0.06	0.08	0.08
Stack Temp. Factor	0.96	0.94	0.95	0.91	0.92	0.85	0.86	0.83	0.83	0.86	0.85
Stack Dilution Factor	4.6	5.4	5.6	5.2	5.9	8.2	7.3	5.4	6.3	8.3	7.0
Boiling of Water Loss	10.9	11.0	11.0	11.2	11.2	11.6	11.6	11.8	11.8	11.5	11.7
CO Loss %	6.5	4.0	13.0	7.4	3.9	3.0	3.2	2.3	2.7	4.4	3.8
HC Loss %	0.90	0.74	2.75	2.39	1.40	1.19	0.41	0.93	0.83	0.95	0.78
Dry Gas Loss %	3.4	5.9	5.5	10.0	10.4	28.5	23.3	22.7	25.0	26.1	24.9
g/kg Condar	1.51	1.22	4.87	4.18	2.38	2.02	0.67	1.56	1.38	1.58	1.30
g/kg CO	57.1	35.2	114.9	65.4	34.1	26.4	28.6	19.9	24.0	38.8	33.4
Combustion Effic.	92.6	95.3	84.2	90.2	94.7	95.8	96.3	96.8	96.5	94.7	95.4
Heat Trans. Effic.	85.7	83.1	83.5	78.8	78.4	59.9	65.1	65.5	63.2	62.4	63.4
Overall Efficiency	79.4	79.2	70.4	71.0	74.3	57.4	62.8	63.4	61.0	59.0	60.5

RUN No.	CA-13	CA-14	CA-15	CA-16	CA-17	CA-18	CA-19	CA-20	CA-21	CA-22	CA-23
Av. Stack Temp	243	227	268	282	235	302	159	213	199	203	199
Av. O2%	18.4	17.2	17.0	18.1	18.5	19.1	17.3	16.8	18.0	17.6	18.7
Av. CO%	0.10	0.08	0.13	0.07	0.05	0.09	0.04	0.09	0.08	0.09	0.06
Stack Temp. Factor	0.87	0.88	0.85	0.84	0.87	0.83	0.92	0.89	0.90	0.89	0.90
Stack Dilution Factor	8.3	5.6	5.3	7.4	8.7	11.6	5.9	5.0	7.3	6.4	9.5
Boiling of Water Loss	11.5	11.4	11.6	11.7	11.5	11.8	11.1	11.4	11.3	11.3	11.3
CO Loss %	5.5	3.0	4.5	3.4	3.0	7.0	1.6	3.1	4.0	3.9	3.8
HC Loss %	0.71	0.70	2.06	2.11	0.57	3.50	0.68	0.84	1.40	2.10	2.30
Dry Gas Loss %	24.9	15.3	18.3	27.5	25.1	47.2	9.1	12.6	16.4	14.7	21.4
g/kg Condar	1.18	1.16	3.58	3.67	0.94	6.34	1.13	1.40	2.39	3.65	4.01
g/kg CO	49.0	26.8	40.0	30.0	26.5	61.4	14.5	27.1	35.0	34.4	33.2
Combustion Effic.	93.7	96.3	93.4	94.5	96.4	89.5	97.7	96.1	94.6	94.0	93.9
Heat Trans. Effic.	63.6	73.3	70.0	60.8	63.4	41.1	79.8	76.0	72.3	74.0	67.3
Overall Efficiency	59.6	70.5	65.4	57.5	61.1	36.8	77.9	73.1	68.4	69.5	63.2

Table 2. Summary of Field (F) and Laboratory (L) PM Factors For Masonry Fireplaces and Heaters, (g/kg)

		Cordwood				Lumber (4x4)
		F	F	L	L	L
		AP-42	AWES	Lopez Corrected	Lopez All	VPI
Masonry Fireplaces						
	Open Standard	17.3	24.9			11.0
	Open Rosin		10.4			12.0
Masonry Heaters						
	All	2.8	2.7	2.4	2.4	1.4
	Underfire		5.7	6.3	6.3	2.8
	Overfire		1.9	1.7	2.2	1.0
	Ratio of Underfire to Overfire PM		3.0	3.7	2.8	2.8
Woodstoves (Non-Cat)						
	Conventional	15.3				
	Phase II	7.3				
Pellet Stoves						
	Non EPA	4.4				
	Phase II	2.1				

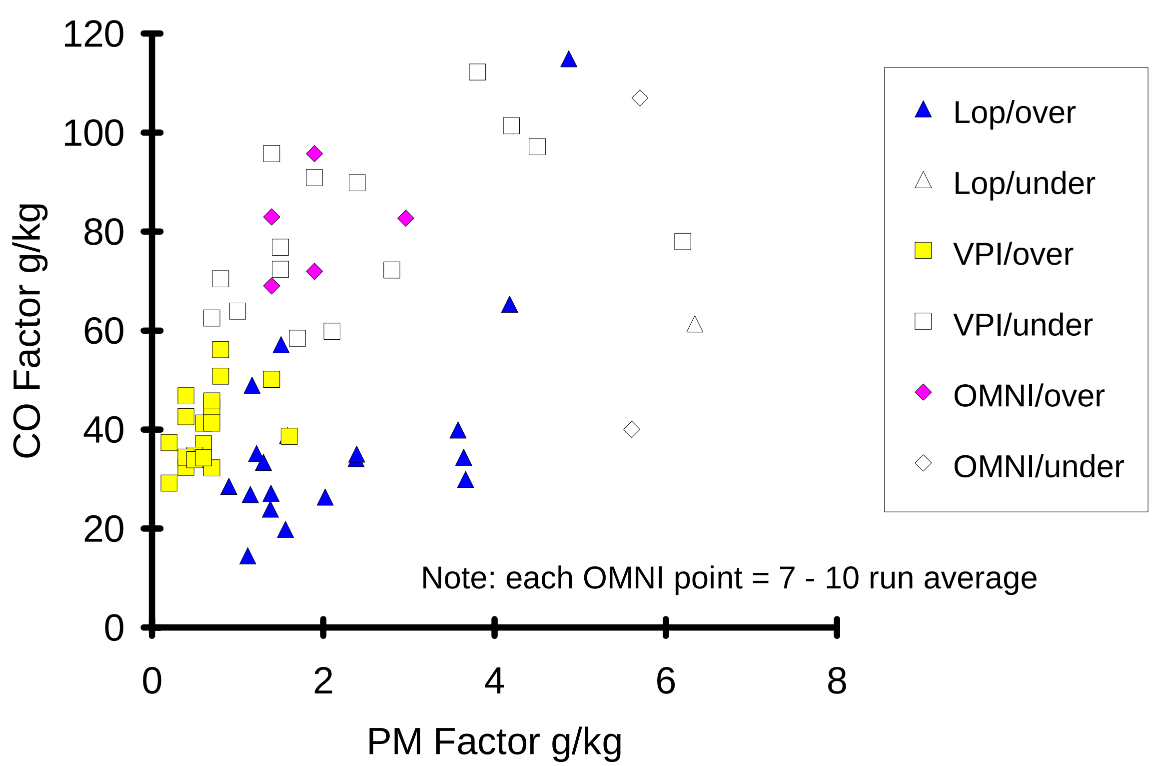


Figure 1. PM:CO correlation, 72 cordwood runs and 34 dimensioned lumber runs.

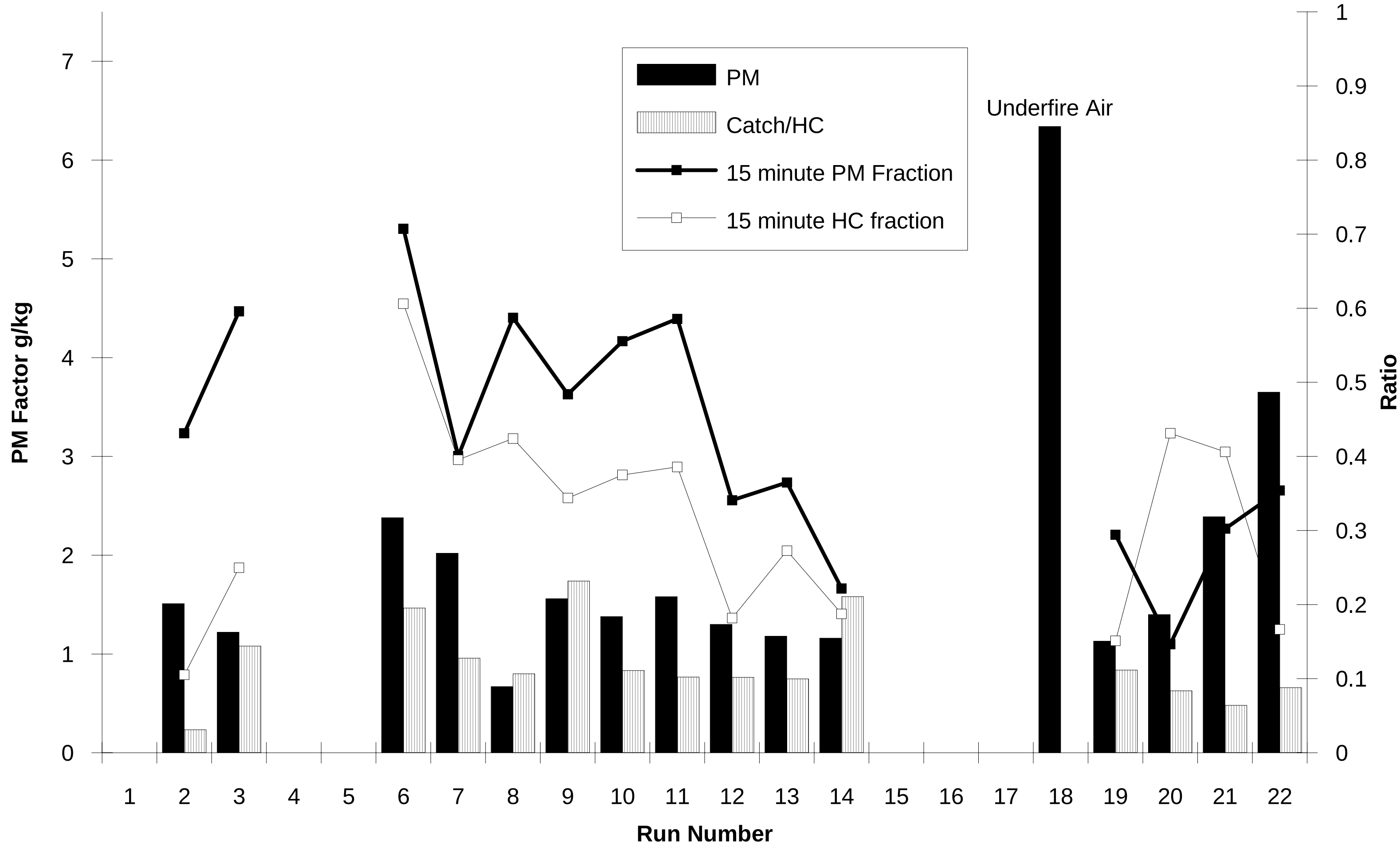


Figure 2. Various relationships between PM and SUN SGA-900 hydrocarbon numbers (overfire contraflow heater).

1994 Lopez Labs Tests - A Preliminary Report

Several Surprises

by Norbert Senf

Jerry Frisch and I conducted a 17 day test series at Lopez Labs last March and April. Jerry had installed a new chimney and damper setup. This allowed us to switch easily between 5 separate units, and on most days we managed to get in all 5 runs. Seventy five new sets of data points were the result. Systems tested were a contraflow (the same HeatKit heater tested in 92 and 93), a Frisch-Rosin (fireplace/heater), a TULIKIVI TK-1200, a standard Rosin (Firecrest) fireplace with an airtight glass door, and a new prototype contraflow heater. A number of heater masons with their own core systems are also planning tests at Lopez.

> Seventy five new sets of data points were the result

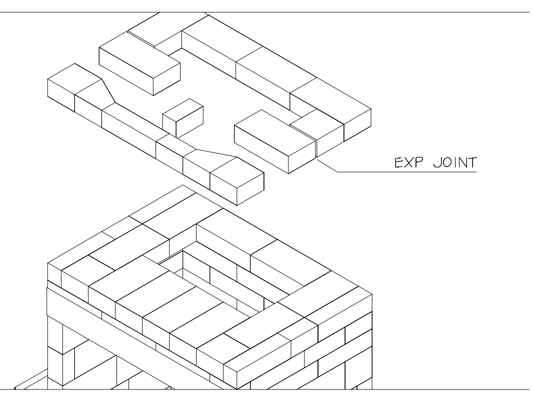
Paul Tiegs from OMNI spent a day at the lab and helped us to evaluate our overall procedures and systems. One major bug did surface, but fortunately was treatable. In prior conversations with Skip Hayden, who heads CCRL, the Canadian government combustion lab, doubts arose as to the accuracy of our oxygen sensor. When a SUN factory technician came by to recalibrate the gas analyzer, he confirmed that the oxygen cell on this type of instrument was not very accurate. In automotive emission testing, oxygen is not an important number and really just acts as a double check on the other gas numbers. Fortunately the other numbers (carbon monoxide (CO), carbon dioxide (CO_2) and hydrocarbons (HC)) are measured by a separate system on the analyzer that is rugged and quite accurate and in fact can recalibrate itself electronically.

In contrast with car emission testing, the oxygen number in masonry heater testing is quite important. It is used to derive the excess air factor, which directly influences the calculations for efficiency and emissions. Fortunately oxygen can be calculated from CO_2 and CO. The chemistry works something like this: A litre of gas at a given temperature and pressure consists of a fixed number of molecules that does not depend on the type of gas. In other words the number of molecules in a litre of oxygen, O_2, and a litre of carbon dioxide, CO_2, is the same. We know that ambient air is 20.9% oxygen and that the CO_2 content is negligible for our purposes. We also know that during wood combustion, the main reaction is the oxidation of carbon, or $C + O_2 > CO_2 +$ heat. Heat and CO_2 are produced, and carbon and oxygen are consumed. Therefore when we see, say 10% CO_2 in the exhaust, we know that roughly 10% of the 20.9% oxygen was used, giving us a calculated oxygen percentage of 10.9. Paul Tiegs explained that with Douglas Fir the $CO_2 + O_2$ in the exhaust actually works out to 20.4 on average, due to the fact that there is also hydrogen in the wood that has a reaction with oxygen ($H_2 + O > H_2O$ + heat).

Accordingly, we were able to work around the oxygen sensor by calculating oxygen from CO_2 and CO. This also allowed us to recalculate all of the 1993 data, which in its uncorrected form was reported in the Summer 93 issue of MHA News and subsequently used as a basis for the AWMA paper.

The second number of great importance to efficiency calculations is the stack temperature. In order to bring our data more in line with AWES methodology, we changed the temperature measuring point in the stack to be 8 feet from the appliance exit. In 93 our thermocouple was higher up in the stack, giving us lower stack temperatures and hence boosting the efficiency numbers. In order not to invalidate the 93 data, we did a series of simultaneous curves on the old and new locations that allowed us to derive a temperature correction factor.

For the 93 data, calculated oxygen turned out to be lower than measured by the O_2 cell. This results in higher efficiency and lower PM. Stack temperature was higher, resulting in lower efficiency with no change in PM. The following chart summarizes the corrected 1993 values. Compare it with the original data, which is summarized at the end of the AWMA paper preceding this article.



Contraflow white oven prototype. Details of oven floor heat bypass, which doubles as a gas-slot for startup.

Summary of 1993 Lopez Labs Test Series - Contraflow (corrected)

Corrected 4/20/94

RUN Number	CF-A02	CF-A03	CF-A04	CF-A05	CF-A06	CF-A07	CF-A08	CF-A09	CF-A10	CF-A11	CF-A12
Av. Stack Temp	178	199	192	246	237	335	318	378	364	315	341
Av. O2%	15.20	16.34	15.92	15.89	16.52	17.52	17.11	16.05	16.51	17.24	16.99
Av. CO%	0.21	0.11	0.35	0.21	0.10	0.05	0.07	0.06	0.06	0.08	0.08
Stack Temp. Factor	0.91	0.90	0.90	0.86	0.87	0.82	0.82	0.79	0.80	0.83	0.81
Stack Dilution Factor	3.66	4.58	4.20	4.17	4.78	6.19	5.51	4.31	4.76	5.72	5.35
Boiling of Water Loss	11.21	11.31	11.28	11.53	11.48	11.94	11.86	12.14	12.07	11.85	11.97
CO Loss %	5.10	3.38	9.81	5.94	3.12	2.26	2.44	1.81	2.06	3.01	2.90
HC Loss %	0.48	0.42	1.48	1.35	0.77	0.61	0.27	0.50	0.42	0.44	0.40
Dry Gas Loss %	7.43	10.92	10.05	14.29	15.13	29.11	30.62	23.15	24.38	24.44	25.24
g/kg Condar	**1.26**	**1.09**	**3.87**	**3.53**	**2.02**	**1.58**	**0.71**	**1.31**	**1.09**	**1.13**	**1.04**
g/kg CO	**45.02**	**29.77**	**86.50**	**52.43**	**27.53**	**19.89**	**21.51**	**15.95**	**18.16**	**26.59**	**25.59**
Combustion Effic.	**94.41**	**96.21**	**88.71**	**92.70**	**96.11**	**97.14**	**97.29**	**97.69**	**97.52**	**96.55**	**96.70**
Heat Trans. Effic.	**81.36**	**77.77**	**78.67**	**74.18**	**73.39**	**58.95**	**57.52**	**64.72**	**63.54**	**63.71**	**62.80**
Overall Efficiency	**76.82**	**74.82**	**69.79**	**68.77**	**70.53**	**57.27**	**55.96**	**63.22**	**61.97**	**61.51**	**60.72**

RUN Number	CF-A13	CF-A14	CF-A15	CF-A16	CF-A17	CF-A18	CF-A19	CF-A20	CF-A21	CF-A22	CF-A23
Av. Stack Temp	243	293	334	348	301	368	225	279	265	269	265
Av. O2%	17.48	16.07	15.69	16.89	17.16	17.83	15.85	14.96	16.51	15.91	17.41
Av. CO%	0.10	0.08	0.13	0.07	0.05	0.09	0.04	0.09	0.08	0.09	0.06
Stack Temp. Factor	0.87	0.84	0.82	0.81	0.83	0.80	0.88	0.85	0.85	0.85	0.85
Stack Dilution Factor	6.11	4.33	4.01	5.21	5.59	6.81	4.14	3.52	4.76	4.19	6.00
Boiling of Water Loss	11.51	11.75	11.94	12.00	11.78	12.09	11.43	11.68	11.61	11.63	11.62
CO Loss %	4.11	2.36	3.43	2.38	1.92	4.07	1.16	2.15	2.60	2.57	2.37
HC Loss %	0.33	0.36	1.09	1.03	0.24	1.48	0.32	0.39	0.63	0.97	1.02
Dry Gas Loss %	18.45	16.86	18.49	26.64	23.71	37.19	12.26	13.75	17.43	15.62	21.45
g/kg Condar	**0.87**	**0.94**	**2.83**	**2.68**	**0.63**	**3.86**	**0.83**	**1.02**	**1.64**	**2.52**	**2.65**
g/kg CO	**36.23**	**20.82**	**30.27**	**21.03**	**16.96**	**35.87**	**10.19**	**18.92**	**22.89**	**22.68**	**20.92**
Combustion Effic.	**95.56**	**97.28**	**95.48**	**96.59**	**97.84**	**94.45**	**98.52**	**97.46**	**96.78**	**96.46**	**96.61**
Heat Trans. Effic.	**70.04**	**71.40**	**69.57**	**61.37**	**64.51**	**50.71**	**76.31**	**74.57**	**70.95**	**72.74**	**66.93**
Overall Efficiency	**66.93**	**69.46**	**66.43**	**59.27**	**63.12**	**47.90**	**75.18**	**72.68**	**68.66**	**70.17**	**64.66**
					dubious	grate					prelim

Comparison of PM and Efficiency, Original and Corrected Values

	Original	Corrected
Average PM, g/kg, all tests	2.37	1.78
PM, underfire (#18)	6.34	3.86
Average Efficiency, all tests	65.5	65.72
Efficiency, underfire (#18)	36.8	47.9

In overall terms, we see about a half gram per kilogram improvement in the average particulate emissions. These averages include all of the runs, including bad runs where we were "messing around". The numbers from the underfire air run, number CF-A18, show the greatest improvement but are still significantly higher in PM and lower in efficiency.

On the efficiency side we see that, overall, things have cancelled out, with the lower oxygen numbers making up for the higher stack temperatures. We also see that a significant percentage of the runs, 23% or 5 out of 22, are in the sub-gram range.

Now for a brief glimpse at the 1994 results - a complete report will appear in the next issue of MHA News.

There was one, very big, surprise this year. We were able to get a standard Rosin fireplace with a glass door to burn in the 1 g/kg range - something that I don't think too many people have so far considered possible. As is often the case in these matters, we weren't even trying, but lucked into it instead. The original plan was to repeat the same burn on this fireplace every day, in order to lay down a baseline for our procedures, ie., repeatability, data scatter, etc. Since the tight schedule limited each heater test to 120 minutes, we often had charcoal left at the end of a run. For the last run of each day, we would load the Rosin with the day's charcoal, shovel in the hot coals from the just-finished run, add a load of wood and then let it rip. As you can imagine, this resulted in some huge fires. We demoed one for Paul Tiegs, and he seemed genuinely surprised to see the complete lack of smoke right from the beginning of the burn with this particular setup. We all attributed it to the hot charcoal start.

...IT APPEARS FEASIBLE TO DEVELOP A BUILDING-CODE BASED DESIGN SPECIFICATION FOR A CLEAN BURNING MASONRY FIREPLACE

A couple of days after Paul left, Jerry decided to see what kind of numbers we would get with a standard fuel load and a cold start. To our amazement, the numbers remained almost the same. This was the same fireplace that we tested last year with various combinations of a standard West Coast 2 "cowbell" air setup, with unimpressive results. The difference this year was a new nozzle and a change in direction of the air - the air was aimed directly at the fire. Interestingly, in CMHC's 1989 publication "Fireplace Air Requirements" we find the following quote:

> "*Concentrating all of the draft on the intake, and directing the air to the woodpile creates an uncontrolled "blow torch" effect, seen both in lab tests and WOODSIM simulations*".

That's pretty much what it was. However, we found that we could reduce the opening to the point where we got a "normal" looking fire, and still maintain the low PM numbers. In effect, what happens is that you take the high draft pressure created by high stack temperatures, and convert all of the draft pressure into inlet air velocity. Efficiency was quite respectable, in the low 50% range. These results should be regarded as preliminary, since most of this happened towards the end of the testing and we didn't have further time or resources to do a more detailed investigation.

It does raise some interesting questions, however, particularly for the masonry fireplace industry. It may well be feasible to develop a building-code based design specification for a clean burning masonry fireplace. Caveats are that the fireplace needs an airtight door and will probably need a lower limit on the minimum burn rate. Sensitivity to operator influence also needs study. Perhaps (if masonry fireplaces don't get legislated out of existence first and the masonry industry can be convinced to get serious about this), the housing development of the future will feature a clean, site-built woodburning masonry fireplace. Its operation may well become a privilege, earned by completing a one-evening course in "biomass awareness".

Now the heaters. We learned quite a bit this year, and will only touch on the highlights in this preliminary installment:

We stopped using the top down burn. Instead, we switched to ignition from the front bottom of the pile, directly in front of the air inlet. It seems that if you can get a fast, full flaming start this way and have the front of the pile ignite, with the flames going up the front and over and completely filling the space above the pile, you can get some good numbers indeed. Again, we seemed to be getting the knack only towards the end of the testing. Just to tantalize you, here are the numbers from the last 4 runs on the new design:

RUN No.	B13	B14	B15	B16
Wood Moisture	20.3	16.8	15.2	17.5
Total Weight, lbs	55.0	45.3	47.3	42.8
Kindling Weight, lbs	1.5	1.5	1.5	1.5
Number of Pieces	8	8	9	8
Surface/Volume	3.60	3.99	3.95	3.97
Run Length, hrs	2.0	2.0	2.0	2.0
Av. Stack Temp, F	410	422	392	374
Av. O2%	14.87	15.50	15.19	15.51
Av. CO%	0.09	0.09	0.08	0.10
Stack Temp. Factor	0.78	0.77	0.79	0.80
Stack Dilution Factor	3.46	3.87	3.66	3.88
Burn Rate dry kg/hr	9.96	8.50	9.06	7.96
Boiling of Water Loss	12.29	12.34	12.20	12.12
CO Loss %	2.03	2.40	1.99	2.51
HC Loss %	0.24	0.17	0.25	0.24
Dry Gas Loss %	20.54	23.75	20.55	20.57
Filter Catch gm.	0.0368	0.0236	0.0368	0.0334

RUN No.	B13	B14	B15	B16
PM, g/kg (Condar)	**0.62**	**0.45**	**0.65**	**0.62**
CO, g/kg	**17.91**	**21.17**	**17.53**	**22.12**
Combustion Effic.	97.73	97.43	97.76	97.25
Heat Trans. Effic.	67.17	63.91	67.25	67.31
Overall Efficiency	65.65	62.27	65.75	65.46
			24hr	

That's right, particulate emissions well into the sub 1 gram range.

These numbers were obtained with a new contraflow heater design that we prototyped specifically for the Lopez testing in order to experiment with several concepts.

The main design goal was to optimize the heater around a white oven. There are a several percentage points of efficiency missing from the above table because we did a bit of bypassing to get floor heat into the oven (see diagram). This is seen in higher stack temperatures, although these shouldn't be a problem to bring down.

The other design goals were:

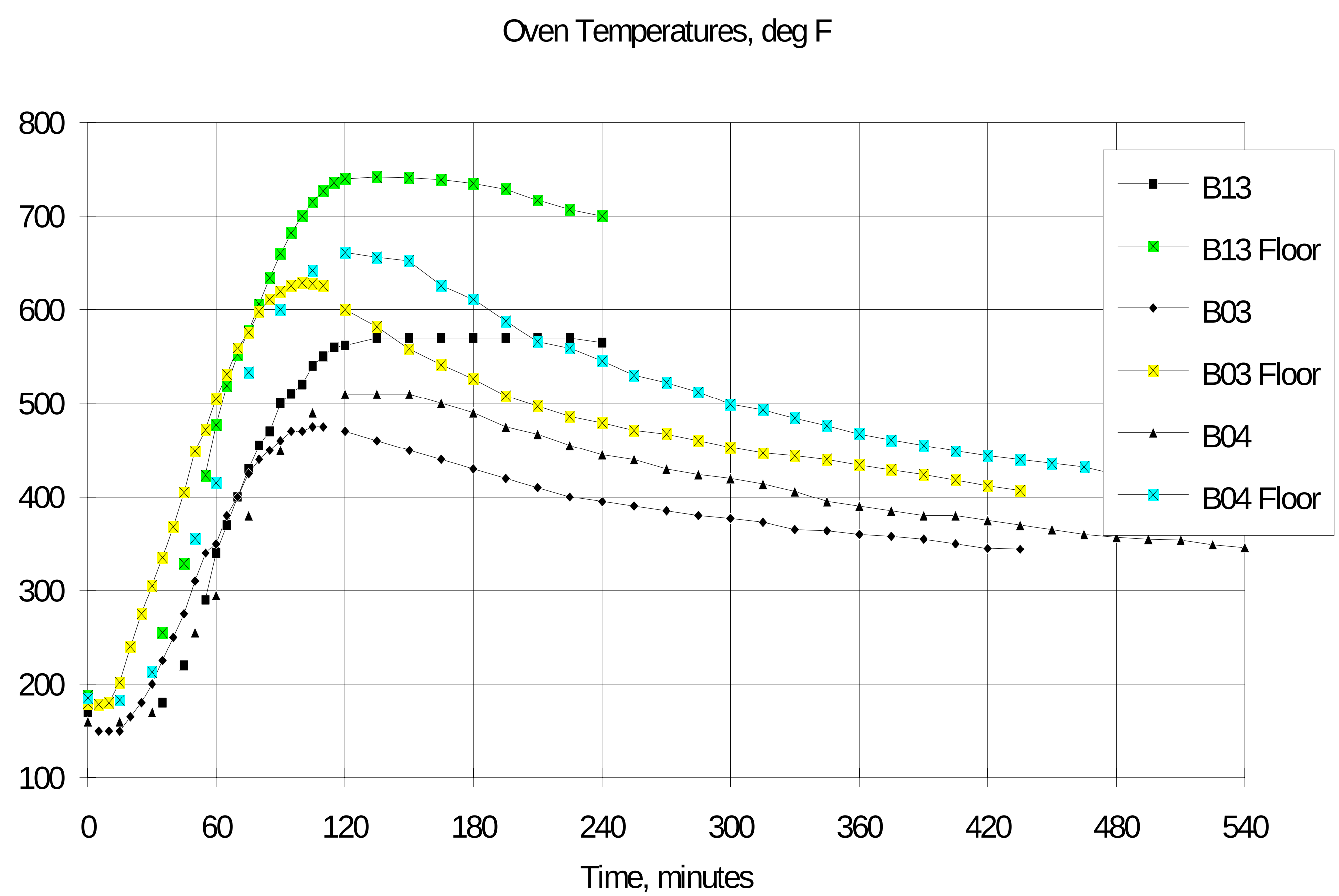
- Keep the oven hearth as low as possible.
- Increase firebox width from 18" to 22.5"
- Eliminate the firebox back wall slope.
- Reduce the weight and number of refractory castings
- Make the firebox replaceable
- Minimize the number of firebrick sawcuts.

Oven performance, as shown in the chart below, was impressive.

Wood weights for the oven runs were as follows:
B03: 40.8 lbs
B04: 42.0 lbs
B13: 55.0 lbs

MHA News will publish a set of construction drawings for this experimental heater in the next issue.

As we headed home from our six week western sojourn, Jerry was intensely preoccupied in applying the new Rosin air design to the Frisch-Rosin. Stay tuned.



MHA VOTING MEMBER LIST AS OF 5/26/95

Name	Company	Address	Town	State/Zip	Tel(B)	FAX	Dues
Gunther Bartsch	DBA Masonry	200 Pepi Drive	Garnerville	NV 89410	(702)782-3008	-	93
Albie Barden	Maine Wood Heat Co.	RFD 1, Box 640	Norridgewock	ME 04957	(207)696-5442	696-5856	94
Ulli Baumhard	Canadian Ceramic Wood Heat	R.R. 1	Sutton West	ON L0E 1R0	(905)478-8843	-	93
David (Buck) Beckett	Thermal Mass Fireplaces	P.O. Box 1562	Jackson Hole	WY 83001	-	-	94
Steve Busch	Maine Masonry Stove Co	Rte 1 Box 569	Buckfield	ME 04220	(207)336-2056	-	93
Steve Bushway	Deer Hill Masonry Heat	224 West St.	Cummington	MA 01026	(413)634-5792	634-5037	94
Gabriel Callender	Foyer Radiant DeBriel	1000 RR 2	Frampton	PQ G0R 1M0	(418)387-8961	386-3600	94
Steve Cohan	Hot Rock Masonry	PO Box 526, Rt. 1, Box 85-S	Eastsound	WA 96245	(206)376-5505	376-5552	94
Rick Crooks	Mutual Materials Co.	PO Box 2009, 605 - 119th Ave. NE	Bellevue	WA 98009	(206)455-2869	454-7732	94
Timothy Custer	Top Hat Chimney Sweeps	12380 Tinkers Creek Rd.	Cleveland	OH 44125	(216)524-5431	-	94
A. Michael D'Arcangelo	Kachelofen Unlimited	1407 Caves Camp Road	Williams	OR 97544	(503)846-6196	-	94
Bill Derrick	Alternate Energy Systems	Star Route Box 344	Peru	NY 12972	(518)643-9374	643-2012	94
Heinz Flurer	Biofire	3220 Melbourne	Salt Lake City	UT 84106	(801)486-0266	486-8100	94
Jerry Frisch	Lopez Quarries	111 Barbara Lane	Everett	WA 98203	(206)353-8963	742-3361	94
Doug Fry	Fry Masonry Construction	66605 N. Lakeview	Sturgis	MI 49091	(616)651-1262	-	94
George Gough	Gough Masonry Ltd.	834 Old River Road	Sault Ste. Marie	ON P6A 6JA	(705)253-4314	945-1408	94
Alan Gossett	Alan Gossett Masonry	11818 Golden Given Rd. E.	Tacoma	WA 98445-3024	(206)537-6077	-	93
Douglas Hargrave	Inverness Masonry Heat	1434 Dairy Rd.	Charlottesville	VA 22903	(804)979-7300	979-6416	94
Jerry Haupt	Kent Valley Masonry	23631 S.E. 216th St.	Maple Valley	WA 98038	(206)432-0134	413-1771	94
Kerry Hill	Cross-Fire Heat Storage Systems Inc.	12159 Brawn Rd.	RR 2 Wainfleet	ON L0S 1V0	(905)899-2432	same	94
Dale Hisler	Lightning Arrow Stove Works	Box 25	Pray	MT 59065	(406)333-4383	-	94
Mike Homchick	Masonry Construction Co.	P.O.Box 82102	Kenmore	WA 98028	(206)481-2783	771-4175	93
Stan Homola	Mastercraft Masonry	P.O. Box 73	Brush Prairie	WA 98606	(206)892-4381	same	94
Steven R. Jackson	Village Sweep Chimney Service	2183 Colorado Ave.	Elgin	IL 60123	(708)742-3583	-	93
David Johnstone	Barclay, Tarr, Walters & Co.	P.O. Box 198	Errington	BC V0R 1V0	(604)248-6535	-	94
Stig Karlberg	Royal Crown	333 E. State - Suite 206	Rockford	IL 61104	(815)968-2022	968-0739	94

John LaGamba	Temp-Cast Enviroheat Ltd.	33320 Yonge St. P.O. Box 94059	Toronto	ON M4M 3R1	(416)322-6084	486-3624	94
David Lyle	Heating Research Co.	Box 300	Acworth	NH 03601	(603)835-6109	-	94
J. Patrick Manley	Brick Stove Works	374 Nelson Ridge Rd.	Washington	ME 04574	(207)845-2440	same	94
Russell May	May's Masonry	4262 William Mill Rd.	Burlington	NC 27215	(919)584-1575	-	93
David McGee	Masonry Concepts	P.O. Box 611	Ocean City	MD 21842	(410)213-7622	-	94
Mark McKusick	Hearth Warmers	RR 1 Box 27	Colrain	MA 01340-9705	(413)624-3363	624-3367	94
Joe McLaughlin	J. McLaughlin Agency	PO Box 14249	East Providence	RI 02914-4249	(800)472-3780	434-5521	94
Walter Moberg	W. Moberg Design/ FireSpaces	921 SW Morrison St. Suite 439-440	Portland	OR 97205	(503)227-0547	227-0548	94
David R. Moore	MTC Construction	11817 Vail Rd. S.E.	Yelm	WA 98597	(206)458-4866	-	94
Erik Nilsen	Thermal Mass Inc.	RR 1 Box 367	Littleton	NH 03561	(603)444-6474	-	94
Brian/Marsha Olenych	Olenych Masonry Inc.	HC 65 Box 3	Bovina Centre	NY 13740	(607)832-4373	832-4561	94
Arthur Olson/Jim Donaldson	European Masonry Heaters Co.	706 California Blvd.	Napa	CA 94559	(707)259-0208	252-1782	94
Jamie Paiken	Jamie Paiken Masonry	600 Cove Rd.	Ashland	OR 97520	(503)482-4379	-	94
Steve Patzer	Patzer & Co. Masonry	3N 743 RTE 32	St. Charles	IL 60174	(708)584-1081	-	94
Martin Pearson	Pearson Masonry	40 Rhodes St.	Cumberland	RI 02864	(401)333-6583	-	94
Ron Pihl	Cornerstone Masonry	Box 83	Pray	MT 59065	(406)333-4383	-	94
Frank Pusatere	Colonial Associates Inc.	48 Radnor Ave.	Croton on Hudson	NY 10520	(914)271-6078	-	94
Keith Roosa	Hickory Mountain Chimney Sweep	P.O. Box Q	Wallkill	NY 12589	(914)895-2750/800-SOOT	-	94
Robert A. Rucker	CMS Industries Inc.	4524 Rt. 104	Williamson	NY 14589	(315)589-4131	(716)662-2068	94
Stanley Sackett	Sackett Brick Co.	1303 Fulford Street	Kalamazoo	MI 49001	(616)381-4757/(800)848-9440	381-2684	94
Fred Schukal	Sleepy Hollow Chimney Supply	85 Emjay Blvd.	Brentwood	NY 11717	(516)231-2333	231-2364	94
Norbert Senf	Masonry Stove Builders	RR 5	Shawville	PQ J0X 2Y0	(819)647-5092	(613)722-6485	94
Tom Stroud	Dietmeyer Ward & Stroud	P.O. Box 323	Vashon	WA 98070	(206)463-3722	463-6335	94
Christine Subasic	Brick Institute of America	11490 Commerce Park Drive	Reston	VA 22091	(703)620-3171	620-3928	94
Tom Trout	Vesta Masonry Stove Inc.	373 Old Seven Mile Ridge Rd.	Burnsville	NC 28714	(704)675-5247 800-473-5240	675-5666	94
Jack West	The New Alberene Stone Company, Inc.	P.O. Box 300	Schuyler	VA 22969	(804)831-2228	831-2732	94
Don & Gary Wilkening	Wilkening Fireplace Co.	HCR 73 Box 625	Walker	MN 56484	(218)547-1988/(800)367-7976	547-3393	94
Ron Williams	Kentuckiana Chimney Inc.	9216 Cornflower Ave.	Louisville	KY 40272	(502)935-0752	-	94
Rod Zander	Artisan's Workshop	127 North Street	Goshen	CT 06756	(203)491-3091	same	94

MHA Associate Member List as of 5/25/94

Lonnie Alexander	Alexander Construction	100 Raintree Rd.	Sedona	AZ 86351	602-284-9669	-	94
Al Bachmann	Bachmann Construction	45 Burroughs Dr.	Madison	WI 53713	222-8869	222-8618	94
Kevin Charyk	Fire Kan Fireplaces	RR 3 Box A5	Sutton West	ON L0E 1R0	(905)476-0065	-	93
Marcus Flynn	Pyro Mass	4390 Coloniale	Montreal	QC H2W 2C6	-	-	93
Sam Foote, P. Eng.	-	Suite 210, 14924 Yonge St. S.	Aurora	ON L4G 6H7	(416)727-6950	-	93
Bob Gossett	BoB Gossett Masonry Design	8204 Midvale Rd.	Yakima	WA 98908	(509)966-9683	-	94
Hope L. Griscom	Hope Griscom Designs	5090 Richmond Ave., Suite 285	Houston	TX 77056	(713)961-1688	961-1687	94
Thomas Hagelund	Armstrong Masonry	Box 139, Rt. 1	Winthrop	NY 13697	(315)328-4883	-	93
Jay Hensley	SNEWS	P.O.Box 98	Wilmore	KY 40390	(606)858-4043	same, call first	recip
Ernst Heuft	The Master Stove Setter	RR 5 15933 26th. Ave.	White Rock	BC V4B 4Z2	(604)531-0987	-	93
Larry James	High Country Stoves	415 S. 5th. St.	Laramie	WY 82070	(307)745-4488	745-4488	94
Geoffrey Kenseth	The Chimney Swift	28 Hulst Road	Amherst	MA 01002	(413)256-0157	-	94
Bill Kjorlien	BIA Region 9	5885 Glenridge Dr. #200	Atlanta	GA 30328	(404)255-7160	843-3278	94
Uwe Mirsch	Holzworks	19 W. 161 Rochdale Circle	Lombard	IL 60148	(708)916-8329	same	93
Walter Pearce	W.E. Pearce Inc.	4161 Kiehl Rd.	Friday Harbor	WA 98250	(206)378-2094	-	93
Christopher Prior	Adirondack Chimney Co.	2315 Rte. 29	Middle Grove	NY 12850	(518)882-6091	882-6091	93
Dr. Ernst Rath	Aug. Rath jun AG	Walfischgasse 14	A-1010 Wien	Austria	+43 1 /513 44 26-0	+43 1 /513 89 17	94
Gene Sengstake		4000 NW 49th Street	Lincoln	NE 68524	-	-	93
Peter Solac	Woodland Way, Inc	1203 Washington Ave. So.	Minneapolis	MN 55415	(612)338-6606	339-3391	94
G. Ronald Telfer	Ronjan Inc.	1540 Charlton Road	Victoria	BC V8X 3X1	604\479-2528	943-0177	93
Alex Wilson	Environmental Building News	RR 1 Box 161	Brattleboro	VT 05301	(802)257-7300	257-7304	recip
Brian Yanik	Ontario Woodheat Leaders	RR 4, 34 York Rd.	Niagara on Lake	ON L0S 1J0	(416)984-8884	984-8469	93
Helmut Ziehe	IBE	P.O. Box 387	Clearwater	FL 34615	(813)461-4371	-	recip
Ken Hooker	Masonry Construction Magazine	426 S. Westgate	Addison	IL 60101	-	-	recip
Naydene Maykut	PSAPCA	110 Union Street, Suite 500	Seattle	WA 98101-2038	-	-	recip